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COMMON WORK RESULTS, DIVISION 21 THROUGH 28

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Notes:

A. Division 21 through 23 specify furnishing variable speed drives. Division 26 specifies mounting and providing power wiring from the electrical panel source through the drive to the motor. Division 23 specifies integration of the drives into the BAS controls.

B. Power to Division 23 Controls Systems: Division 26 specifies providing spare 20A - 120V circuit breakers in branch circuit panelboards for BAS controllers and other Division 23 global control systems components. Branch circuits from breakers are specified in Division 26. Interconnecting wiring to BAS is specified in Division 23.

C. Divisions supplying system control wiring includes installation of open wiring system supports.

D. Division 28 specifies providing separate contacts in the fire alarm panel for zones and operational modes required for building smoke control. Interconnecting wiring to BAS is specified in Division 23.

E. Components and wiring required for monitoring Division 26 – 28 equipment outlined below are specified in Division 23 according to the Division 26 - 28 Specifications. Refer to Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operation for HVAC Controls." Monitoring shall include:
   1. Medium Voltage Transformer Fans.
   3. TVSS Failure.
   4. Protective Device Positions.
   5. Electric Power Management System.
   7. UPS Status.

F. Division 23 specifies installation of muffler(s), muffler insulation, and exhaust piping condensation drain(s). Extend drains to local floor drain(s).

G. Division 06 specifies providing plywood equipment backboards. Installation coordination is specified in Division 26 to comply with conduit rough-in systems requirements.

H. Division 08 specifies requirements of door frame rough-in. Other associated conduit rough-in is specified in Division 26.

I. Division 26 specifies providing sleeves for cables for Division 21 - 28 systems cabling requirements.

J. Division 07 specifies providing Firestopping, including Firestopping for Division 21 – 28 systems pathway and cabling requirements.

K. Division 07 specifies fire-rated cable assemblies for Division 21 - 28 cabling firestopping requirements for horizontal cabling pass-through at the fire walls.

L. Division 08 specifies providing access panels. Size and location coordination is specified as drawing submittals by applicable Divisions 21 – 28.

M. Division 02 specifies removal of all exposed abandoned cable. Refer to Division 02 Section "Selective Demolition."

END OF SECTION 200525
SECTION 200530 – FUNCTIONAL PERFORMANCE TESTING COMMON WORK RESULTS, DIVISION 21 THROUGH 28

PART 1 - GENERAL

1.1 CLOSEOUT SUBMITTALS

A. Submit functional performance test schedule to Architect/Engineer through Construction Manager to allow test witness coordination.

B. Submit functional performance testing and witness list for Architect/Engineer approval prior to final punch list and request for substantial completion.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 FUNCTIONAL PERFORMANCE TESTING

A. Location of Subject Matter: Specified information pertaining to facility service functional performance testing can be found in the following locations:

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B. Submit functional performance test results for each system complete with witness signatures by involved Divisions.

END OF SECTION 200530
SECTION 200535 – SYSTEMS CERTIFICATIONS COMMON WORK RESULTS, DIVISION 21 THROUGH 28

PART 1 - GENERAL

1.1 CLOSEOUT SUBMITTALS

A. Submit certification test schedule to Architect/Engineer through Construction Manager to allow test witness coordination.

B. Submit certificates for Architect/Engineer approval prior to final punch list and request for substantial completion.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 CERTIFICATES

A. Submit the following certifications for approval in one package:

1. General:
   a. List of uncompleted items from the Architect’s and Engineer’s observation reports and punch lists.
      Enclosed __________ N/A, why? ________________________________
   b. Documents by the installer that all fire extinguishers have been checked and inspection tags are dated and attached to each device.
      Enclosed __________ N/A, why? ________________________________
      Enclosed __________ N/A, why? ________________________________

2. Division 21:
   a. Certification by the installer that the sprinkler system is installed as required by NFPA 13, Chapter 10, NFPA 20, Chapter 11 and NFPA 14, Chapter 9. Submit copy of the sprinkler acceptance and/or hydrostatic test report.
      Enclosed __________ N/A, why? ________________________________
   b. Documentation by the installer that other fire extinguishment systems (halon, for example) have been tested and checked for the purpose of determining compliance with the appropriate NFPA standard for the system being used.
   c. Provide the documentation of all certifications and test data verifying that the fire pump and system components have been installed and tested per NFPA 20, Chapter 11 Acceptance Testing, Performance & Maintenance and NFPA 25, Chapter 5, 5-3.3.4, Emergency Power Operation and Chapter 9 Back-Flow Preventers.
      Enclosed __________ N/A, why? ________________________________

3. Division 22:
   a. Non-Flammable Medical Gas and Vacuum Systems Certification. Submit a complete copy of the third party certification per NFPA 99, 1999 4-3.4.1.3.
      Enclosed __________ N/A, why? ________________________________
4. Division 23:
   a. Certification of the HVAC system has been installed and is operating in compliance with the design plans and specifications. NFPA 90A/90B and/or the local Authority Requirements.
      Enclosed _________ N/A, why? ________________________________
   b. Documentation by the installer that range hood and duct systems are installed and operate in accordance with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations."
      Enclosed _________ N/A, why? ________________________________
   c. Certification by the installer that the smoke control system has been tested and operates as designed per NFPA 92.
      Enclosed _________ N/A, why? ________________________________
   d. Certification of the installation and testing of each fume hood per NFPA 45 and ASHRAE HVAC Application Handbook (1995 Edition), Chapter 13, specific to each classroom.
      Enclosed _________ N/A, why? ________________________________

5. Division 26:
   a. Certification by the electrical system installer that the electrical systems have been installed and all electrical work has been performed in accordance with the applicable NFPA 70 – National Electrical Code.
      Enclosed _________ N/A, why? ________________________________
   b. Certification by the installer that the lighting control electronic timers and occupancy sensors have been installed, adjusted, tested and found to operate in accordance with the specifications.
      Enclosed _________ N/A, why? ________________________________
   c. Certification by the installer that the networked and dimmers lighting control systems have been installed, adjusted, tested and found to operate in accordance with the specifications.
      Enclosed _________ N/A, why? ________________________________
   d. Certification by the installer that the emergency generator has been installed to meet the licensure standards, NFPA 99 "Health Care Facilities" and NFPA 110 "Emergency and Standby Power Systems". The generator must be operational for the inspection. Include initial 4-hour acceptance test documentation.
      Enclosed _________ N/A, why? ________________________________
   e. Certification of the installations and testing of ground-fault protection in electrical switchboards per NFPA 70-230-95C(c) and NFPA 70-517.17(c).
      Enclosed _________ N/A, why? ________________________________

6. Division 27:
   a. Certification by the installer that the nurse call system has been installed, tested and found to operate in accordance with the specifications.
      Enclosed _________ N/A, why? ________________________________
   b. Certification by the installer that that the nurse call systems have been installed, adjusted, tested and found to operate in accordance with the specifications.
      Enclosed _________ N/A, why? ________________________________
7. Division 28:
   a. Certification by the installer of the fire alarm system has been installed, tested and is in compliance with the applicable NFPA 72 – Fire Alarm Systems.
      Enclosed __________ N/A, why? ________________________________
   b. Certification by the installer that the elevator recall system is installed and operates in accordance with ANSI A17.1 "Safety code for Elevators and Escalators".
      Enclosed __________ N/A, why? ________________________________
   c. Certification by the installer that the security systems have been installed, adjusted, tested and found to operate in accordance with the specifications.
      Enclosed __________ N/A, why? ________________________________

END OF SECTION 200535
SECTION 210500 - BASIC DIVISION 21 REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following:
   1. Piping materials and installation instructions common to most piping systems.
   2. Mechanical sleeve seals.
   3. Sleeves.
   4. Core Drilling
   5. Escutcheons.
   7. Fire-suppression equipment and piping demolition.
   8. Equipment installation requirements common to equipment sections.
   10. Concrete bases.
   11. Supports and anchorages.

1.2 DEFINITIONS
A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlsaces, and tunnels.
B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
F. Abbreviation that remains after this Section has been edited. The following are industry abbreviations for plastic materials:
G. The following are industry abbreviations for rubber materials:
   1. EPDM: Ethylene-propylene-diene terpolymer rubber.
   2. NBR: Acrylonitrile-butadiene rubber.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 21 Section "Basic Division 21 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data:
   1. Mechanical sleeve seals.
   2. Escutcheons.
1.5 QUALITY ASSURANCE
   A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code-Steel."
   B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
      1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
      2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
   C. Electrical Characteristics for Fire-Suppression Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING
   A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
   B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION
   A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for fire-suppression installations.
   B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
   C. Coordinate requirements for access panels and doors for fire-suppression items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
   D. Coordinate all wiring for alarm devices including alarm valves, flow switches, pressure switches, and tamper switches with Division 28 Section "Fire Detection and Alarm" specified in this Section.

1.8 OWNER REVIEW OF INSTALLATION
   A. At substantial completion, Contractor will schedule a walk-through with Owner to review locations and accessibility of items requiring routine maintenance and access. Items found to be inaccessible shall be relocated to area acceptable to Owner at no cost to Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Basis of Design: Per the manufacturer listed.
   B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.
C. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS
   A. Refer to individual Division 21 piping Sections for pipe, tube, and fitting materials and joining methods.
   B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS
   A. Refer to individual Division 21 piping Sections for special joining materials not listed below.
   B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
      1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
         a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
         b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
      2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
   C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
   D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
   E. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 MECHANICAL SLEEVE SEALS
   A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
      1. Manufacturers:
         a. Advance Products & Systems, Inc.
         b. Calpico, Inc.
         c. Metraflex Co.
         d. Pipeline Seal and Insulator, Inc.
      2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
      3. Pressure Plates: Plastic. Include two for each sealing element.
      4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.
2.5 SLEEVES
A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40. galvanized, plain ends.
C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with set screws.

2.6 ESCUTCHEONS
A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID too closely fit around pipe, tube, and installation of piping and an OD that completely covers opening.
B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
C. One-Piece, Cast-Brass Type: With set screw.
   1. Finish: Polished chrome-plated.
D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated.
E. One-Piece, Stamped-Steel Type: With set screw and chrome-plated finish.
F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw, and chrome-plated finish.
G. One-Piece, Floor-Plate Type: Cast-iron floor plate.
H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.7 GROUT
A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume adjusting, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION
3.1 FIRE-SUPPRESSION DEMOLITION
A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.
B. Disconnect, demolish, and remove fire-suppression systems, equipment, and components indicated to be removed.
   1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: NONE ALLOWED, UNLESS APPROVED BY PLANT OPERATIONS.
   a. Drain piping and cap or plug piping with same or compatible piping material.
   b. Install "ABANDONED SPRINKLER PIPING" per pipe labeling Section.211000.

3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
6. Sprinkler Heads to Be Removed and Salvaged: Prior to turnover to Owner, remove all temporary turned up sprinkler heads only after permanent turned down sprinkler heads are installed. Deliver temporary sprinkler heads to owner.

C. If pipe, or equipment to remain is damaged in appearance or is unserviceable, notify the general contractor and Froedtert’s representative immediately prior to any removal of any damaged or unserviceable portions.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 21 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping exposed piping and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs ARE PROHIBITED unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
   1. Minimum will be 8” the ceiling tile thickness as measured from the top of the grid.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Only the piping serving electric rooms, tel/data rooms or computer rooms shall be installed in or above these rooms. Piping passing through these rooms is NOT ACCEPTABLE and shall not be installed.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
   1. New Piping:
a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
c. Insulated Piping: One-piece, stamped-steel type with spring clips.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
g. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and set screw.
j. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw.
l. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
m. Bare Piping through Exterior Walls: One-piece, stainless steel or chrome plated plastic.

2. Existing Piping: Use the following:
   a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
   b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge and spring clips.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
   g. Bare Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated finish.
   h. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge and set screw or spring clips.
   i. Bare Piping in Equipment Rooms: Split-casting, cast-brass type.
   j. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
   k. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

M. Sleeves are not required for core-drilled holes, unless requested by the Owner and Engineer.
N. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
O. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.
a. Exception: Extend sleeves installed in floors where piping is exposed i.e.: stairwells 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

b. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 6 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
   a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
   b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 6 inches above finished floor level. Refer to Division 07 Section “Sheet Metal Flashing and Trim” for flashing.

1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section “Joint Sealants” for materials and installation.

P. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron “wall pipes” for sleeves 6 inches larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Q. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron “wall pipes” for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section “Penetration Firestopping” for materials.

S. Verify final equipment locations for roughing-in.

T. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.
3.3 CORE DRILLING
A. Perform all core drilling required for the installation of the fire protection system. Locate all required openings and prior to coring coordinate the opening with the Construction Manager. Thoroughly investigate the existing conditions in the vicinity of the required opening prior to coring. Care must be taken so as not to disturb the existing building systems. Locate all other openings required for the Construction Manager. Patching of existing walls and openings shall be performed by the respective trade responsible for the finish material in which the opening is made.

B. Before coring is performed, submit drawings showing location of cores to structural engineers for their review.

C. All floor locations that are to core drilled are required to have the core area X-rayed prior to cutting.

3.4 PIPING JOINT CONSTRUCTION
A. Join pipe and fittings according to the following requirements and Division 21 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.


F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 PAINTING
A. Painting of fire-suppression systems, equipment, and components are specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

C. Exposed sprinkler piping to be painted red a minimum of two coats. See Division 9 for specifications for ferrous metals.
3.6 CONCRETE BASES
   A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
      1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported equipment.
      2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
      3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
      4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
      5. Install anchor bolts to elevations required for proper attachment to supported equipment.
      6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
      7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Miscellaneous Cast-in-Place Concrete."

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES
   A. Refer to Division 05 Section "Metal Fabrications" for structural steel.
   B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor fire-suppression materials and equipment.
   C. Field Welding: Comply with AWS D1.1.

3.8 GROUTING
   A. Mix and install grout for fire-suppression equipment base bearing surfaces, pump and other equipment base plates, and anchors.
   B. Clean surfaces that will be exposed to grout.
   C. Provide forms as required for placement of grout.
   D. Avoid air entrapment during placement of grout.
   E. Place grout, completely filling equipment bases.
   F. Place grout on concrete bases and provide smooth bearing surface for equipment.
   G. Place grout around anchors.
   H. Cure placed grout.

END OF SECTION 210500
SECTION 211000 - WATER-BASED FIRE-SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following fire-suppression piping inside the building:
   1. Automatic wet-type, Class I standpipe systems.
   2. Wet-pipe sprinkler systems.
   3. Dry-pipe sprinkler systems.
   4. Preaction sprinkler systems.

B. Related Sections include the following:
   1. Division 10 Section "Fire Extinguisher Cabinets" and "Fire Extinguishers" for cabinets and fire extinguishers.
   2. Division 22 Section "Facility Water Distribution Piping" for piping outside the building.
   3. Division 28 Section "Fire Detection and Alarm" for alarm devices not specified in this Section.

1.2 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. High-Pressure Piping System: Fire-suppression piping system designed to operate at a working pressure higher than standard 175 psig.

C. PE: Polyethylene plastic.

D. Underground Service-Entrance Piping: Underground service piping below the building.

1.3 SYSTEM DESCRIPTIONS

A. Combined Standpipe and Sprinkler System: Fire-suppression system with both standpipe and sprinkler systems. Sprinkler system is supplied from standpipe system.

B. Automatic Wet-Type, Class I Standpipe System: Includes NPS 2-1/2 hose connections. Has open water-supply valve with pressure maintained and is capable of supplying water demand.

C. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and is connected to water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.

D. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing compressed air or nitrogen. Opening of sprinklers releases compressed air or nitrogen and permits water pressure to open dry-pipe valve. Water then flows into piping and discharges from opened sprinklers.

E. Preaction Sprinkler System: Automatic sprinklers are attached to piping containing air. Actuation of fire-detection system in same area as sprinklers opens deluge valve, permitting water to flow into piping and to discharge from sprinklers that have opened.

1.4 PERFORMANCE REQUIREMENTS


B. High-Pressure Piping System Component Working Pressure: Listed for 300 psig.
C. Fire-suppression standpipe system design shall be approved by authorities having jurisdiction and the owner's insurance underwriter.
   1. Minimum residual pressure at each hose-connection outlet is the following:
      a. NPS 2-1/2 Hose Connections: 100 psig.
   2. Unless otherwise indicated, the following is maximum residual pressure at required flow at each hose-connection outlet:
      a. NPS 2-1/2 Hose Connections: 175 psig.

D. Fire-suppression sprinkler system design shall be approved by authorities having jurisdiction and the owner's insurance underwriter.
   1. Margin of Safety for Available Water Flow and Pressure: 10-psi minimum, including losses through water-service piping, valves, and backflow preventers.
   2. Velocity shall not exceed 20 feet per second (FPS).
   3. For dry pipe systems, include an additional 30% of floor area.
   4. Sprinkler Occupancy Hazard Classifications:
      a. Automobile Parking Areas: Ordinary Hazard, Group 1.
      b. Building Service Areas: Ordinary Hazard, Group 1.
      c. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
      d. General Storage Areas: Ordinary Hazard, Group 1.
      e. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
      f. Office and Public Areas: Light Hazard.
      g. Patient Rooms: Light Hazard.
      h. Operating Rooms: Light Hazard.
      i. Exam and related Rooms: Light Hazard.

5. Minimum Density for Automatic-Sprinkler Piping Design:
   a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
   b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.
   c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area.
   d. Extra-Hazard, Group 1 Occupancy: 0.30 gpm over 2500-sq. ft. area.
   e. Extra-Hazard, Group 2 Occupancy: 0.40 gpm over 2500-sq. ft. area.
   f. Special Occupancy Hazard: As determined by authorities having jurisdiction.

6. Maximum Protection Area per Sprinkler: Per UL listing.

7. Maximum Protection Area per Sprinkler:
   a. Office Spaces: 225 sq. ft.
   b. Storage Areas: 130 sq. ft.
   c. Mechanical Equipment Rooms: 130 sq. ft.
   d. Electrical Equipment Rooms: 130 sq. ft.
   e. Other Areas: According to NFPA 13 recommendations, unless otherwise indicated.

8. Total Combined Hose-Stream Demand Requirement: According to NFPA 13, unless otherwise indicated:
   a. Light-Hazard Occupancies: 100 gpm for 30 minutes.
   b. Ordinary-Hazard Occupancies: 250 gpm for 60 to 90 minutes.
   c. Extra-Hazard Occupancies: 500 gpm for 90 to 120 minutes.
E. Sprinkler systems are to be zoned by floor: Sprinkler zones shall be provided with a floor control valve, flow switch and tamper switch. Additional zoning shall be provided as shown on the plans. Provide additional zone for commercial kitchen areas for new construction. Sprinkler zoning shall not exceed the guidelines identified in the NFPA guidelines for floor area and hazard.

1. The sprinkler piping shall be looped between risers. Piping arrangements shall be complete with control valves, flow switches, tamper switches, check valves, and inspectors test assemblies complete with drains as required by NFPA 13.
2. Inspectors test valve assemblies shall be provided at the remote end of each zone. Test assemblies shall be provided with site glasses and hard-piped express drains to hub drains or at drain risers at standpipe locations. Hub drain locations shall be coordinated with the plumbing contractor.
3. The sprinkler zones shall be in accordance with the barriers of smoke compartments.

F. Electric Rooms/Closets, Elevator Machine Rooms, Telephone Rooms, and IT Closets: Shall be sprinklered in accordance with NFPA 13.

1.5 SUBMITTALS
A. General: Submit the following in accordance with Division 21 Section "Basic Division 21 Requirements."

1.6 ACTION SUBMITTALS
A. Product Data: For the following:
1. Piping materials, including dielectric fittings, flexible connections, and sprinkler specialty fittings.
2. Pipe hangers and supports.
3. Valves, including listed fire-protection valves, unlisted general-duty valves, and specialty valves and trim.
4. Air compressors, including electrical data.
5. Excess-pressure pumps, including electrical data.
6. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other pertinent data.
7. Hose connections, including size, type, and finish.
8. Monitors.
10. Fire department connections, including type; number, size, and arrangement of inlets; caps and chains; size and direction of outlet; escutcheon and marking; and finish.
11. Alarm devices, including electrical data.

B. Shop Drawings:
1. Provide copies to the electrical contractor for coordination.

C. Delegated Design Services:
1. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction and owner’s insurance underwriter, including hydraulic calculations.
a. The working plans and hydraulic calculations shall be prepared by a NICET-Certified Level III or IV automatic sprinkler engineering technician, stamped by a professional engineer registered in the applicable state.

b. The working plans and hydraulic calculations shall be submitted to the owner's representative.

2. Hydraulic Calculations: The hydraulic calculations shall include the hydraulically most remote area for systems supplied by more than one combination riser. Hydraulic calculations shall show the remote areas being supplied solely from the hydraulically most remote combination riser.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For standpipe and sprinkler specialties to include in emergency, operation, and maintenance manuals.

B. Record Documents:

1. Final Field Quality Controls Test Reports:


b. Fire-Hydrant Flow Test Report:

1) The report shall include the test date, testing agency, static pressure, residual pressure, flow rate and hydrant locations including a site plan.

2. Actual Field-Based As-Builts:

a. As-Built Drawings: Prior to turnover to Owner, submit revised shop drawings of all sprinkler plans, details, risers, and other system elements showing actual built conditions.

3. Zone Plans: Along with field-based as-builts, provide zone plans indicating rooms served by each sprinkler riser valve.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing fire-suppression systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire hydrant flow test.

a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer and NICET-Certified Level III or IV, registered in the applicable state.

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

C. NFPA Standards: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13, "Installation of Sprinkler Systems."

2. NFPA 14, "Installation of Standpipe, Private Hydrant, and Hose Systems."
D. Insurance Underwriter: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the owner’s insurance underwriter.

E. Campus Standards: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the campus standards.

F. State Fire Marshal: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the State Fire Marshal.

G. State Building Code: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the State Building Code.

H. Underwriters’ Laboratory: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with Underwriters’ Laboratory.

I. To assure uniformity and compatibility of piping components in grooved piping systems, all grooved products utilized shall be supplied by a single manufacturer. Grooving tools shall be supplied from the same manufacturer as the grooved components.

1.9 COORDINATION

A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

1.10 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounting, steel cabinet with hinged cover, with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include SEPARATE cabinet with sprinklers and wrench for each type of sprinkler on Project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: Per the manufacturer listed.

B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

C. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell end and plain end.

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.

2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron gland, rubber gasket, and steel bolts and nuts.
B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell end and plain end.
1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Gaskets: AWWA C111, rubber.

C. Grooved-End, Ductile-Iron Pipe: AWWA C151, with factory- or field-formed, radius-cut-grooved ends according to AWWA C606.
1. Grooved-Joint Piping Systems:
   a. Manufacturers:
      1) Tyco Fire & Building Products LP
      2) Victaulic Co. of America.
   c. Grooved-End-Pipe Couplings: AWWA C606, gasketed fitting matching ductile-iron-pipe OD. Include ductile-iron housing with keys matching ductile-iron-pipe and fitting grooves, synthetic rubber gasket with center leg, and steel bolts and nuts.
   d. Grooved-End-Pipe Transition Coupling: UL 213 and AWWA C606, gasketed fitting with end matching ductile-iron-pipe OD and end matching steel-pipe OD. Include ductile-iron housing with key matching ductile-iron-pipe groove and key matching steel-pipe groove, synthetic rubber gasket listed for use with housing, and steel bolts and nuts.
   e. Grooved-End Transition Flange: UL 213, gasketed fitting with key for ductile-iron-pipe dimensions. Include flange-type, ductile-iron housing with rubber gasket listed for use with housing and steel bolts and nuts.

2.3 STEEL PIPE AND FITTINGS
A. Threaded-End, Standard-Weight, Schedule 40 Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795, hot-dip galvanized where indicated and with factory- or field-formed threaded ends.
   1. Locking-Lug Fittings: UL 213, ductile-iron body with retainer lugs that require one-quarter turn to secure pipe in fitting.
      a. Manufacturers:
         1) Anvil International, Inc.
         2) Ward Manufacturing.
   2. Steel Flanges and Flanged Fittings:  ASME B16.5.

D. Grooved-End, Standard-Weight, Schedule 40 Steel Pipe:  ASTM A 53/A 53M, ASTM A 135, or ASTM A 795, hot-dip galvanized where indicated and with factory- or field-formed, square-cut- or roll-grooved ends.
   1. Grooved-Joint Piping Systems:
      a. Manufacturers:
         1) Anvil International, Inc.
         2) Tyco Fire & Building Products LP
         3) Wheatland Tube Co.
         4) Victaulic Co. of America.
      b. Grooved-End Fittings:  UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD.
      c. Grooved-End-Pipe Couplings:  UL 213 and AWWA C606, rigid pattern, unless otherwise indicated; gasketed fitting matching steel-pipe OD.  Include ductile-iron housing with keys matching steel-pipe and fitting grooves, pre-lubricated rubber gasket listed for use with housing, and steel bolts and nuts.
         1) Rigid Type:  Housings shall be cast with offsetting, angle-pattern bolt pads to provide system rigidity and support and hanging in accordance with NFPA 13.
            a) 2" through 8":  "Installation Read" stab-on design, for direct ‘stab’ installation onto grooved end pipe without prior field disassembly and no loose parts.
            b) 10" and Larger:  Standard rigid coupling.

E. Plain-End, Schedule 10 Steel Pipe:  ASTM A 135 or ASTM A 795, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10.
   1. Locking-Lug Fittings:  UL 213, ductile-iron body with retainer lugs that require one-quarter turn to secure pipe in fitting.
      a. Manufacturers:
         1) Anvil International, Inc.
         2) Ward Manufacturing.

F. Plain-End, Schedule 10 Steel Pipe:  ASTM A 135 or ASTM A 795, Schedule 10 in NPS 5 and smaller; and NFPA 13 specified wall thickness in NPS 6 to NPS 10.
   2. Steel Flanges and Flanged Fittings:  ASME B16.5.

G. Grooved-End, Schedule 10 Steel Pipe:  ASTM A 135 or ASTM A 795, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10; with factory- or field-formed, roll-grooved ends.
   1. Grooved-Joint Piping Systems:
      a. Manufacturers:
         1) Anvil International, Inc.
2) Tyco Fire & Building Products LP
3) Wheatland Tube Co.
4) Victaulic Co. of America.

b. Grooved-End Fittings: UL-listed, ASTM A536, ductile-iron casting with OD matching steel-pipe OD.
c. Grooved-End-Pipe Couplings: UL 213 and AWWA C606, rigid pattern, unless otherwise indicated; gasketed fitting matching steel-pipe OD. Include ductile-iron housing with keys matching steel-pipe and fitting grooves, pre-lubricated rubber gasket listed for use with housing, and steel bolts and nuts.

1) Rigid Type: Housings shall be cast with offsetting, angle-pattern bolt pads to provide system rigidity and support and hanging in accordance with NFPA 13.
   a) 2" through 8": "Installation Read" stab-on design, for direct 'stab' installation onto grooved end pipe without prior field disassembly and no loose parts.
   b) 10" and Larger: Standard flexible coupling.

2.4 COPPER TUBE AND FITTINGS

A. Soft Copper Tube: ASTM B 88, Type K, water tube, annealed temper; with plain ends.
   2. Brazing Filler Metals: AWS A5.8, BCuP-3 or BCuP-4.
   4. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match tubing system.
   5. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body with ball-and-socket metal-to-metal seating surfaces, and solder-joint or threaded ends.

B. Plain-End, Hard Copper Tube: ASTM B 88, Type L, water tube, drawn temper.
   2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match tubing system.
   3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body with ball-and-socket metal-to-metal seating surfaces, and solder-joint or threaded ends.
   4. Grooved-Joint Systems:
      a. Manufacturers:
         1) Anvil International, Inc.
         2) Victaulic Co. of America.
      b. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting with copper-tube dimensioned grooved ends (flaring of tube and fitting ends to IPS dimensions is not permitted).
c. Grooved-End-Tube Couplings: UL 213, rigid pattern, unless otherwise indicated; gasketed fitting equivalent to AWWA C606 but made to match copper-tube OD. Include ductile-iron housing cast with offsetting, angle-pattern bolt pads coated with copper colored enamel with keys matching steel-pipe and fitting grooves, synthetic rubber gasket listed for use with housing, and steel bolts and nuts. Couplings shall be "Installation Read" stab-on design, for direct 'stab' installation onto roll grooved copper tube without prior field disassembly and no loose parts.

2.5 DIELECTRIC FITTINGS

A. Assembly shall be copper alloy, ferrous, and insulating materials with ends matching piping system.

B. Dielectric Unions: Factory-fabricated assembly, designed for 250-psig minimum working pressure at 180°F. Include insulating material that isolates dissimilar materials and ends with inside threads according to ASME B1.20.1.

1. Manufacturers:
   a. Capitol Manufacturing Co.
   b. Epco Sales, Inc.
   e. Zurn Industries, Inc.; Wilkins Div.

C. Dielectric Flanges: Factory-fabricated companion-flange assembly, for 175-psig minimum working-pressure rating as required for piping system.

1. Manufacturers:
   a. Capitol Manufacturing Co.

D. Dielectric Flange Insulation Kits: Components for field assembly shall include CR or phenolic gasket, PE or phenolic bolt sleeves, phenolic washers, and steel backing washers.

1. Manufacturers:
   a. Advance Products and Systems, Inc.
   b. Calpico, Inc.
   c. Pipeline Seal and Insulator, Inc.

E. Dielectric Couplings: Galvanized steel with inert and noncorrosive thermoplastic lining and threaded ends and 300-psig working-pressure rating at 225 deg F.

1. Manufacturers:
   a. Calpico, Inc.
   b. Lochinvar Corp.

F. Dielectric Nipples: Electroplated steel with inert and noncorrosive thermoplastic lining, with combination of plain, threaded, or grooved ends and 300-psig working-pressure rating at 225 deg.

1. Manufacturers:
   a. Perfection Corporation.
   b. Victaulic Co. of America.
2.6 FLEXIBLE, SPRINKLER HOSE FITTINGS:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Victaulic.

B. Standard: UL 2443.

C. Type: Fully stainless-steel flexible hose for connection to sprinkler, and with one-piece open-gate bracket for connection to ceiling grid. Bracket to allow for installation before ceiling tile is in place.

D. Hose: UL approved braided hose with a bend radius to 2” to allow for proper installation in confined spaces.

E. Union joints shall be provided for ease of installation.

F. Pressure Rating: 175 psig minimum.

G. Size: Same as connected piping, for sprinkler.

2.7 FLEXIBLE CONNECTORS

A. Flexible connectors shall have materials suitable for system fluid. Include 175-psig minimum 300-psig minimum working-pressure rating and ends according to the following:
   1. NPS 2 and Smaller: Threaded.
   2. NPS 2-1/2 and Larger: Flanged.
   3. Option for NPS 2-1/2 and Larger: Grooved for use with grooved-end-pipe couplings.

B. Manufacturers:
   1. Anamet Inc.
   2. Flex-Hose Co., Inc.
   3. Flexicraft Industries.
   4. Flex-Pression, Ltd.
   5. Flex-Weld, Inc.
   6. Hyspan Precision Products, Inc.
   7. Mercer Rubber Co.
   8. Metraflex, Inc.
   9. Proco Products, Inc.
   10. Unaflex, Inc.

C. Bronze-Hose, Flexible Connectors: Corrugated, bronze, inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze welded to hose.

D. Stainless-Steel-Hose/Steel Pipe, Flexible Connectors: Corrugated, stainless steel, inner tubing covered with stainless-steel wire braid. Include steel nipples or flanges, welded to hose.

E. Stainless-Steel-Hose/Stainless-Steel Pipe, Flexible Connectors: Corrugated, stainless steel, inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to hose.

2.8 CORROSION-PROTECTIVE ENCASEMENT FOR PIPING

A. Encasement for Underground Metal Piping: ASTM A 674 or AWWA C105, PE film, 0.008-inch minimum thickness, tube or sheet.
2.9 SPRINKLER SPECIALTY FITTINGS

A. Sprinkler specialty fittings shall be UL listed, with 175-psig minimum working-pressure rating, and made of materials compatible with piping. Sprinkler specialty fittings shall have 300-psig working-pressure rating if fittings are components of high-pressure piping system.

B. Sprinkler Drain and Alarm Test Fittings: Cast- or ductile-iron body; or bronze body, with threaded or grooved inlet and outlet, test valve, and orifice and sight glass.

1. Manufacturers:
   a. Fire-End and Croker Corp.
   b. Tyco Fire & Building Products LP.
   c. Viking Corp.
   d. Victaulic Co. of America.

C. Sprinkler Branch-Line Test Fittings: Brass body with threaded inlet, capped drain outlet, and threaded outlet for sprinkler.

1. Manufacturers:
   b. Fire-End and Croker Corp.
   c. Potter-Roemer; Fire-Protection Div.

D. Sprinkler Inspector’s Test Fitting: Cast- or ductile-iron or bronze housing with grooved inlet and drain outlet and sight glass.

1. Manufacturers:
   a. AGF Manufacturing Co.
   b. Victaulic.

E. Drop-Nipple Fittings: UL 1474, adjustable with threaded inlet and outlet, and seals.

1. Manufacturers:
   a. CECA, LLC.
   b. Merit.

F. Flexible Sprinkler Drops: UL listed, braided, flexible hose.

1. Manufacturers:
   a. FlexHead.
   b. Victaulic Co. of America.
   c. SuperFlex, Viking Corp.
   d. Easyflex
   e. SprinkFLEX.

G. Dry-Pipe-System Fittings: UL listed for dry-pipe service.

2.10 LISTED FIRE-SUPPRESSION VALVES

A. Valves shall be UL listed, with 175-psig minimum pressure rating. Valves shall have 300-psig pressure rating if valves are components of high-pressure piping system. All valves capable of isolating the fire suppression systems shall be complete with a supervisory switch.

B. Gate Valves with Wall Indicator Posts:
1. Gate Valves: UL 262, cast-iron body, bronze mounted, with solid disc, non-rising stem, operating nut, and flanged ends.

2. Indicator Posts: UL 789, horizontal-wall type, cast-iron body, with operating wrench, extension rod, locking device, and cast-iron barrel.

3. Manufacturers:
   b. McWane, Inc.; Kennedy Valve Div.
   c. NIBCO.
   d. Stockham.

C. Ball Valves: Comply with UL 1091, except with ball instead of disc.

1. NPS 1-1/2 and Smaller: Bronze body with threaded or grooved ends.

2. NPS 2: Bronze body with threaded ends or grooved ends.

3. Manufacturers:
   a. NIBCO.
   b. Victaulic Co. of America.

D. Butterfly Valves: UL 1091: With Plant Operations approval only

1. NPS 2 and Smaller: Bronze body with threaded ends.

a. Manufacturers:
   1) Global Safety Products, Inc.
   2) Milwaukee Valve Company.

2. NPS 2-1/2 and Larger: Bronze, cast-iron, or ductile-iron body; wafer type or with flanged or grooved ends.

a. Manufacturers:
   1) McWane, Inc.; Kennedy Valve Div.
   2) Mueller Company.
   3) NIBCO.
   4) Pratt, Henry Company.
   5) Tyco Fire & Building Products LP.
   6) Victaulic Co. of America.

E. Check Valves NPS 2 and Larger: UL 312, swing type, cast-iron body with flanged or grooved ends.

1. Manufacturers:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Hammond Valve.
   d. McWane, Inc.; Kennedy Valve Div.
   e. Mueller Company.
   f. NIBCO.
   g. Reliable Automatic Sprinkler Co., Inc.
   h. Stockham.
   i. Tyco Fire & Building Products LP.
   j. Victaulic Co. of America.

F. Gate Valves: UL 262, OS&Y type.

1. NPS 2 and Smaller: Bronze body with threaded ends.
a. Manufacturers:
   1) Crane Co.; Crane Valve Group; Crane Valves.
   2) Hammond Valve.
   3) NIBCO.
   4) United Brass Works, Inc.

2. NPS 2-1/2 and Larger: Cast-iron body with flanged ends.
   a. Manufacturers:
      1) Clow Valve Co.
      2) Crane Co.; Crane Valve Group; Crane Valves.
      3) Crane Co.; Crane Valve Group; Jenkins Valves.
      4) Hammond Valve.
      5) Milwaukee Valve Company.
      6) Mueller Company.
      7) NIBCO.
      8) United Brass Works, Inc.

3. NPS-2-1/2 and Larger: Ductile iron body with grooved ends.
   a. Manufacturers:
      1) Victaulic.

G. Indicating Valves: UL 1091, with integral indicating device and ends matching connecting piping.
   1. Indicator: Electrical, 115-V AC, prewired, single-circuit, supervisory switch.
   2. NPS 2 and Smaller: Ball or butterfly valve with bronze body and threaded ends.
      a. Manufacturers:
         1) Milwaukee Valve Company.
         2) NIBCO.
         3) Victaulic Co. of America.

3. NPS 2-1/2 and Larger: With Plant Operations approval only: Butterfly valve with cast- or ductile-iron body; wafer type or with flanged or grooved ends.
   a. Manufacturers:
      1) Grinnell Fire Protection.
      2) McWane, Inc.; Kennedy Valve Div.
      3) Milwaukee Valve Company.
      4) NIBCO.
      5) Victaulic Co. of America.

2.11 UNLISTED GENERAL-DUTY VALVES
A. Ball Valves NPS 2 and Smaller: MSS SP-110, 2-piece copper-alloy body with chrome-plated brass ball, 600-psig minimum CWP rating, blowout-proof stem, and threaded ends.

B. Check Valves NPS 2 and Smaller: MSS SP-80, Type 4, Class 125 minimum, swing type with bronze body, nonmetallic disc, and threaded ends.

C. Gate Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, solid wedge, and threaded ends.
D. Globe Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, nonmetallic disc, and threaded ends.

2.12 SPECIALTY VALVES

A. Sprinkler System Control Valves: UL listed cast- or ductile-iron body with flanged or grooved ends, and 175-psig minimum pressure rating. Control valves shall have 300-psig pressure rating if valves are components of high-pressure piping system.

1. Manufacturers:
   a. Reliable Automatic Sprinkler Co., Inc.
   b. Victaulic Co. of America.
   c. Viking Corp.

2. Alarm Check Valves: UL 193, designed for vertical installation, with bronze grooved seat with O-ring seals, single-hinge pin, and latch design. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer. Valve internal components shall be replaceable without removing the valve from the installed position.
   a. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
   b. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

3. Dry-Pipe Valves: UL 260, differential type; with brass seat with Nitrile O-ring seals, single-hinge pin, and latch design. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment. Minimum required air pressure is 13 psi with low-pressure actuator: 300 psig water working pressure in all sizes. Valve shall be installed in the vertical position only. Valve internal components shall be replaceable without removing the valve from the installed position and shall be externally resettable.
   a. Air-Pressure Maintenance Device: UL 260, automatic device to maintain correct air pressure in piping. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig adjustable range, and 175-psig maximum inlet pressure.
      1) Available Manufacturers:
         a) Reliable Automatic Sprinkler Co., Inc.
         b) Viking Corp.
   b. Air Compressor: UL 753, fractional horsepower, 120-V ac, 60 Hz, single phase.
      1) Available Manufacturers:
         a) Gast Manufacturing, Inc.
         b) Grinnell Fire Protection.
         c) Reliable Automatic Sprinkler Co., Inc.
         d) Viking Corp.
   c. Air Maintenance/Compressor Assembly:
      1) Available Manufacturers:
         a) Victaulic Company.
2) UL listed, Riser mounted compressor, [1/6] [1/3] [1/2] fractional horsepower, 120-Vac, 60 HA, single phase, assembled with Series 757P air maintenance device and flexible hoses. Designed to ensure operational air pressure within 30 minutes of discharge in accordance with NFPA 13 requirements.

d. Nitrogen Generator:

4. Deluge Valves: UL 260, ductile-iron body, hydraulically operated, low differential-pressure type. Include seat with Nitrile O-ring seals, trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, drip cup assembly piped without valves and separate from main drain line, fill-line attachment with strainer, and push-rod chamber supply connection. Valve shall be installed in the vertical position only Valve internal components shall be replaceable without removing the valve from the installed position and shall be externally resettable.


b. Dry, Pilot-Line Trim Set: Include dry, pilot-line actuator; air- and water-pressure gages; low-air-pressure warning switch; air relief valve; and pneumatically activated low-pressure actuation device. Dry, pilot-line actuator includes cast-iron, operated, diaphragm-type valve with resilient facing plate, resilient diaphragm, and replaceable bronze seat. Valve includes threaded water and air inlets and water outlet. Loss of air pressure on dry, pilot-line side allows pilot-line actuator to open and causes deluge valve to open immediately.

B. Pressure-Regulating Valves: UL 1468, brass or bronze, NPS 1-1/2 and NPS 2-1/2, 400-psig minimum rating. Include female NPS inlet and outlet, adjustable setting feature, and straight or 90-degree-angle pattern design as indicated.

1. Finish: Rough metal.

2. Available Manufacturers:

b. Fire-End and Croker Corp.
c. GMR International Equipment Corporation.
d. Grinnell Fire Protection.
e. Potter-Roemer; Fire Protection Div.
f. Zurn Industries, Inc.; Wilkins Div.

C. Automatic Drain Valves: UL 1726, NPS 3/4, ball-check device with threaded ends.

1. Manufacturers:

a. AFAC, Inc.
b. Grinnell Fire Protection.

2.13 CONTROL PANELS

A. Description: Single-area, two-area, or single-area cross-zoned type control panel as indicated, including NEMA ICS 6. Type 1 enclosure, detector, alarm, and solenoid-valve circuitry for operation of deluge valves. Panels contain power supply; battery charger; standby batteries; field-wiring terminal strip; electrically supervised solenoid valves and polarized fire alarm bell; lamp test facility; single-pole, double-throat auxiliary alarm contacts; and rectifier.

1. Panels: UL listed when used with thermal detectors and Class A detector circuit wiring. Electrical characteristics are 120-V ac, 60 Hz, with 24-V dc rechargeable batteries.
2. Manual Control Stations: Electric operation, metal enclosure, labeled "MANUAL CONTROL STATION" with operating instructions and a cover held closed by breakable strut.

3. Manual Control Stations: Hydraulic operation, with union, NPS 1/2 pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut.

2.14 EXCESS-PRESSURE PUMPS

A. Description: UL-listed, factory-fabricated, positive-displacement, gear-type pump assembly. Include controls, wet-pipe kit, switches, fittings, valves, mounting brackets, and connections for power, hydraulic piping, and wiring from alarm devices.

1. Pump and Motor: Directly connected.
2. Motors: Comply with requirements in Division 21 Section "Common Motor Requirements for Fire Suppression Equipment."
4. Lights: To indicate sprinkler system operating condition.
   a. White Light: Pressure is normal.
   b. Red Light: Pressure is low.
   c. Pump Capacity: Approximately 1 gpm (63 mL/s).
   d. Pump Discharge Head: Approximately 45 psig (310 kPa) above supply pressure and limited to 175 psig (1200 kPa).
   e. Motor: 1/4 hp, 115-V ac, 60 Hz.

5. Available Manufacturers:
   a. Gamewell Company (The).

2.15 SPRINKLERS

A. Sprinklers shall be UL listed, with 175-psig minimum pressure rating. Sprinklers shall have 300-psig pressure rating if sprinklers are components of high-pressure piping system.

B. Sprinklers shall be glass bulb type. Body shall be die cast brass with hex shaped wrench boss cast into the body to facilitate installation and reduce the risk of damage during installation.

C. Manufacturers: Create a matrix
   1. Reliable Automatic Sprinkler Co., Inc.
   2. Tyco Fire & Building Products LP.
   3. Victaulic Co.
   4. Viking Corp.

D. Automatic Sprinklers: With heat-responsive element complying with the following:
   1. UL 199, for nonresidential applications.
   2. UL 1767, for early-suppression, fast-response applications.
   3. Flexible sprinkler head connections: Stainless steel construction, UL-listed with restraint bracket

E. Sprinkler Types and Categories: Nominal 1/2-inch orifice for "Ordinary" temperature classification rating, unless otherwise indicated or required by application.
      a. Orifice: 1/2 inch, with discharge coefficient K between 5.3 and 5.8.
      b. Orifice: 17/32 inch, with discharge coefficient K between 7.4 and 8.2.
F. Sprinkler types, features, and options as follows:
   1. Concealed ceiling sprinklers, including cover plate. BASIN OF DESIGN
   2. Extended-coverage sprinklers.
   3. High-pressure sprinklers.
   4. Quick-response sprinklers.
   5. Sidewall sprinklers.
   6. Sidewall, dry-type sprinklers.
   7. Upright sprinklers.

G. Sprinkler Finishes: Chrome plated, bronze, and painted.

H. Special Coatings: Nickel Teflon, wax, lead, and corrosion-resistant paint.

I. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
   1. Ceiling Mounting: Chrome-plated steel, one piece, flat.
   2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

J. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler.

K. Sprinkler escutcheons and guards shall be listed, supplied and approved for use with the sprinkler, by the sprinkler manufacturer.

2.16 HOSE CONNECTIONS

A. Manufacturers:
   2. Fire-End and Croker Corp.
   3. Fire Protection Products, Inc.
   4. GMR International Equipment Corporation.
   5. Grinnell Fire Protection.
   7. McWane, Inc.; Kennedy Valve Div.
   10. Tyco Fire & Building Products LP.

B. Description: UL 668, brass or bronze, 300-psig (2070-kPa) minimum pressure rating, hose valve for connecting fire hose. Include [angle] [angle or gate] [gate] pattern design; female NPS inlet and male hose outlet; and lugged cap, gasket, and chain. Include NPS 1-1/2 or NPS 2-1/2 (DN 40 or DN 65) as indicated, and hose valve threads according to NFPA 1963 and matching local fire department threads.
   1. Valve Operation: [Nonadjustable type] [Nonadjustable type, unless pressure-regulating type is indicated] [Pressure-regulating type].
   2. Finish: Rough metal or chrome-plated.

2.17 MONITORS

A. Available Manufacturers:
   2. Fire-End and Croker Corp.
4. Potter-Roemer; Fire-Protection Div.

B. Description: Stationary, single-waterway-type monitor for 750-gpm water stream. Include the following features:
1. Waterway: NPS 2-1/2 minimum, brass or stainless-steel tube.
2. Operation: Lever handle.
3. Horizontal Rotation: 360 degrees with locking device.
4. Vertical Rotation: 80-degree elevation and 60-degree depression with locking device.
5. Nozzle: UL 401, NPS 2-1/2, brass, adjustable from fog spray to straight stream to shutoff.

2.18 WALL-TYPE FIRE HYDRANTS

A. Available Manufacturers:
2. Guardian Fire Equipment Incorporated.
3. Potter-Roemer; Fire-Protection Div.

B. Description: Cast-brass-body fire hydrant with brass wall escutcheon plates, brass lugged caps with gaskets and brass chains, and brass lugged swivel connections. Include outlets with threads according to NFPA 1963 and matching local fire department sizes and threads, inlet with pipe threads, extension pipe nipple, and valve control.
1. Type: Flush with [one hose-connection outlet] [two hose-connection outlets] and square or rectangular escutcheon plate.
2. Type: Exposed, projecting, with two hose-connection outlets and round escutcheon plate.
4. Hydrant Escutcheon-Plate Marking: "HYDRANT."
6. Hydrant Valve-Control Escutcheon-Plate Marking: "HYDRANT VALVE CONTROL."

2.19 FIRE DEPARTMENT CONNECTIONS

A. Available Manufacturers:
2. Fire-End and Croker Corp.
3. GMR International Equipment Corporation.
5. Potter-Roemer; Fire-Protection Div.
6. Reliable Automatic Sprinkler Co., Inc.
7. Tyco Fire & Building Products LP.

B. Wall-Type, Fire Department Connection: UL 405, 175-psig minimum pressure rating; with corrosion-resistant-metal body with brass inlets, brass wall escutcheon plate, brass lugged caps with gaskets and brass chains, and brass lugged swivel connections. Include inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, outlet with pipe threads, extension pipe nipples, check devices or clappers for inlets, and escutcheon plate with marking similar to "AUTO SPKR & STANDPIPE."
1. Type: Flush, with [two] [three] [four] <Insert other> inlets and square or rectangular escutcheon plate.

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2. Type: Exposed, projecting, with two inlets and round escutcheon plate.

C. Exposed, Freestanding-Type, Fire Department Connection: UL 405, [175-psig minimum] [300-psig] pressure rating; with corrosion-resistant-metal body, brass inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, and bottom outlet with pipe threads. Include brass lugged caps, gaskets, and brass chains; brass lugged swivel connection and drop clapper for each hose-connection inlet; 18-inch- high, brass sleeve; and round, floor, brass escutcheon plate with marking "AUTO SPKR & STANDPIPE."


2.20 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Water-Motor-Operated Alarm: UL 753, mechanical-operation type with pelton-wheel operator with shaft length, bearings, and sleeve to suit wall construction and 10-inch- diameter, cast-aluminum alarm gong with red-enamel factory finish. Include NPS 3/4 inlet and NPS 1 drain connections.

1. Available Manufacturers:
   a. Firematic Sprinkler Devices, Inc.
   c. Grinnell Fire Protection.
   d. Reliable Automatic Sprinkler Co., Inc.
   e. Star Sprinkler, Inc.
   f. Tyco Fire & Building Products LP.
   g. Viking Corp.

C. Electrically Operated Alarm: UL 464, with 6-inch- minimum diameter, vibrating-type, metal alarm bell with red-enamel factory finish and suitable for outdoor use.

1. Available Manufacturers:
   b. System Sensor.

D. Water-Flow Indicator: UL 346, electrical-supervision, paddle-operated-type, water-flow detector with 250-psig pressure rating and designed for horizontal or vertical installation. Include two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.

1. Available Manufacturers:
   a. ADT Security Services, Inc.
   b. Grinnell Fire Protection.
   c. ITT McDonnell & Miller.
   d. Potter Electric Signal Company.
   e. System Sensor.
   f. Viking Corp.
   g. Watts Industries, Inc.; Water Products Div.

E. Pressure Switch: UL 753, electrical-supervision-type, water-flow switch with retard feature. Include single-pole, double-throw, normally closed contacts and design that operates on rising pressure and signals water flow.
1. Available Manufacturers:
   b. Potter Electric Signal Company.
   c. System Sensor.
   d. Viking Corp.

F. Valve Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled valve is in other than fully open position.

1. Available Manufacturers:
   a. McWane, Inc.; Kennedy Valve Div.
   b. Potter Electric Signal Company.
   c. System Sensor.

G. Indicator-Post Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled indicator-post valve is in other than fully open position.

1. Available Manufacturers:
   b. System Sensor.

2.21 PRESSURE GAGES

A. Available Manufacturers:
   1. AGF Manufacturing Co.
   2. AMETEK, Inc.; U.S. Gauge.
   5. Marsh Bellofram.
   6. WIKA Instrument Corporation.

B. Description: UL 393, 3-1/2- to 4-1/2-inch- diameter, dial pressure gage with range of [0 to 250 psig minimum] [0 to 300 psig].
   1. Water System Piping: Include caption "WATER" or "AIR/WATER" on dial face.
   2. Air System Piping: Include retard feature and caption "AIR" or "AIR/WATER" on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13, NFPA 14 and NFPA 291. Use results for system design calculations required in Part 1 "Quality Assurance" Article.

B. Notifications: Notify the authorities having jurisdiction at least three working days in advance of performing the flow test.

C. Perform test as close as possible to new wet-tap connection for new fire service.
   1. Pressure drop from static to residual shall be at least 25 percent of the static pressure. The flow at the residual pressure shall meet or exceed the preliminary estimated design flow. Open additional hydrant butts as required to obtain the specified pressure drop or to match the preliminary estimated design flow.
D. Record elevations of the test hydrants and submit hydraulic graph(s) indicating test results for review and approval before submitting hydraulic calculations and working plans.

E. Hydraulic graph shall indicate elevation adjustments and water supply curve at wet-tap connection.

F. Report test results promptly and in writing.

3.2 EARTHWORK

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.3 EXAMINATION

A. Examine roughing-in for hose connections and stations to verify actual locations of piping connections before installation.

B. Examine walls and partitions for suitable thicknesses, fire- and smoke-rated construction, framing for hose-station cabinets, and other conditions where hose connections and stations are to be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 HYDRAULICALLY CALCULATED SPRINKLER SYSTEM

A. The Contractor shall provide a hydraulically designed system in complete accordance with and as defined in applicable National Fire Protection Standards and the design guidelines of this project manual and contract documents.

B. Verification of Hydraulic Information:
   1. The contractor shall perform hydrant flow tests and (or) fire pump tests, to establish water supply availability. Water supply information shall be provided on shop drawings as outlined in NFPA 13.
   2. The Contractor shall confirm that hazard classifications/density requirements, if noted on the contract drawings, conform to the Owner's fire insurance underwriter's requirements and those of other authorities having jurisdiction.

C. Accompanying sprinkler shop drawings submitted to the Architect shall bear all sprinkler system requirements, water supply data, graph and work sheets all as defined by NFPA. The hydraulic graph shall include the following information:
   1. Hydrant flow test curve.
   2. Adjust flow test for friction and elevation at new wet tap connection.
   3. System friction loss curve for sprinkler system with inside hose stream.
   5. Fire pump discharge curve.

D. All calculations shall assume a 10-psi deterioration in static and residual pressures in the hydrant flow test results.

E. Velocity shall not exceed 20 FPS for protection of piping integrity.

F. In addition to the above noted requirements, the hydraulic calculations shall include:
   1. The hydraulically most remote area for each hazard classification/density requirements as noted on the contract documents.
3.5 **PIPING APPLICATIONS, GENERAL**

A. Shop weld pipe joints where welded piping is indicated.

B. Do not use welded joints for galvanized-steel pipe.

C. Flanges, flanged fittings, unions, nipples, and transition and special fittings with finish and pressure ratings same as or higher than system's pressure rating may be used in aboveground applications, unless otherwise indicated.

D. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel Schedule 40 pipe with [threaded ends; cast- or malleable-iron threaded fittings; and threaded] [grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints].


F. Underground Service Entrance Piping: Type K, soft copper tube, wrought copper fittings and brazed joints. Include corrosion protective encasement.

3.6 **STANDPIPE SYSTEM PIPING APPLICATIONS**

A. Standard-Pressure, Wet-Type Standpipe System, 175-psig Maximum Working Pressure:

1. NPS 4 and Smaller: Threaded-end, black or galvanized, standard-weight schedule 40 steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.

2. NPS 4 and Smaller: Plain-end, black, standard-weight schedule 40 steel pipe; steel welding fittings; and welded joints.

3. NPS 4 and Smaller: Grooved-end, black or galvanized, standard-weight schedule 40 steel pipe with square-cut- or roll-grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

4. NPS 4 and Smaller: Plain-end, Schedule 10 steel pipe; steel welding fittings; and welded joints.

5. NPS 4 and Smaller: Grooved-end, Schedule 10 steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

6. NPS 5 and NPS 6: Threaded-end, black or galvanized, standard-weight schedule 40 steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.

7. NPS 5 and NPS 6: Plain-end, black, standard-weight schedule 40 steel pipe; steel welding fittings; and welded joints.

8. NPS 5 and NPS 6: Grooved-end, black or galvanized, standard-weight schedule 40 steel pipe with square-cut- or roll-grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

9. NPS 5 and NPS 6: Plain-end, Schedule 10 steel pipe; steel welding fittings; and welded joints.

10. NPS 5 and NPS 6: Grooved-end, Schedule 10 steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

B. High-Pressure, Wet-Type Standpipe System, 175- to 250-psig Working Pressure:

1. NPS 4 and Smaller: Threaded-end, black or galvanized, standard-weight schedule 40 steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.

2. NPS 4 and Smaller: Plain-end, black, standard-weight schedule 40 steel pipe; steel welding fittings; and welded joints.

3. NPS 4 and Smaller: Grooved-end, black or galvanized, standard-weight schedule 40 steel pipe with square-cut- or roll-grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
4. NPS 5 and NPS 6: Threaded-end, black or galvanized, standard-weight schedule 40 steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
5. NPS 5 and NPS 6: Plain-end, black, standard-weight schedule 40 steel pipe; steel welding fittings; and welded joints.
6. NPS 5 and NPS 6: Grooved-end, black or galvanized, standard-weight schedule 40 steel pipe with square-cut- or roll-grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

C. Standard-Pressure, Dry-Type Standpipe System, 175-psig Maximum Working Pressure:
1. NPS 4 and Smaller: Threaded-end, galvanized, standard-weight schedule 40 steel pipe; galvanized, cast- or malleable-iron threaded fittings; and threaded joints.
2. NPS 4 and Smaller: Grooved-end, galvanized, standard-weight schedule 40 steel pipe with square-cut- or roll-grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
3. NPS 4 and Smaller: Grooved-end, galvanized, Schedule 30 steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
4. NPS 5 and NPS 6: Threaded-end, galvanized, standard-weight schedule 40 steel pipe; galvanized, cast- or malleable-iron threaded fittings; and threaded joints.
5. NPS 5 and NPS 6: Grooved-end, galvanized, standard-weight schedule 40 steel pipe with square-cut- or roll-grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

D. High-Pressure, Dry-Type Standpipe System, 175- to 250-psig Working Pressure:
1. NPS 4 and Smaller: Threaded-end, galvanized, standard-weight schedule 40 steel pipe; galvanized, cast- or malleable-iron threaded fittings; and threaded joints.
2. NPS 4 and Smaller: Grooved-end, galvanized, standard-weight schedule 40 steel pipe with square-cut- or roll-grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
3. NPS 5 and NPS 6: Threaded-end, galvanized, standard-weight schedule 40 steel pipe; galvanized, cast- or malleable-iron threaded fittings; and threaded joints.
4. NPS 5 and NPS 6: Grooved-end, galvanized, standard-weight schedule 40 steel pipe with square-cut- or roll-grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

3.7 SPRINKLER SYSTEM PIPING APPLICATIONS
A. Standard-Pressure, Wet-Pipe Sprinkler System, 175-psig Maximum Working Pressure:
1. NPS 1-1/2 and Smaller: Threaded-end, black or galvanized, standard-weight schedule 40 steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
2. NPS 2- to NPS 3-1/2: Grooved-end, Schedule 10 steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
3. NPS 4 to NPS 6: Grooved-end, Schedule 10 steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

B. High-Pressure, Wet-Pipe Sprinkler System, 175- to 250-psig Working Pressure:
1. NPS 1-1/2 and Smaller: Threaded-end, black or galvanized, standard-weight Schedule 40 steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
2. NPS 2 to NPS 4: Plain-end, Schedule 10 steel pipe; steel welding fittings; and welded joints.
3. NPS 5 to NPS 6: Grooved-end, black or galvanized, standard-weight Schedule 40 steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

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C. Standard-Pressure, Dry-Pipe Sprinkler System, 175-psig Maximum Working Pressure:
   1. Sprinkler-Piping Fitting Option: Specialty sprinkler fittings, NPS 2, NPS 2-1/2 or NPS 3 and smaller, including mechanical-T and -cross fittings, may be used downstream from sprinkler zone valves.
   2. NPS 1-1/2 and Smaller: Threaded-end, galvanized, standard-weight Schedule 40 steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
   3. NPS 2: Grooved-end, galvanized, Schedule 10 steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
   4. NPS 2-1/2 to NPS 3-1/2: Grooved-end, galvanized, standard-weight Schedule 40 steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
   5. NPS 4 to NPS 6: Grooved-end, galvanized, standard-weight Schedule 40 steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

D. High-Pressure, Dry-Pipe Sprinkler System, 175- to 250-psig Working Pressure:
   1. NPS 1-1/2 and Smaller: Threaded-end, galvanized, standard-weight Schedule 40 steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
   2. NPS 2 to NPS 3-1/2: Grooved-end, galvanized, standard-weight Schedule 40 steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
   3. NPS 4 to NPS 6: Grooved-end, galvanized, standard-weight Schedule 40 steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

3.8 VALVE APPLICATIONS
   A. Drawings indicate valve types to be used. Any valve that can isolate the water supply to the fire suppression systems shall be provided with a tamper switch with connection to the fire alarm system. Where specific valve types are not indicated, the following requirements apply:
      1. Listed Fire-Protection Valves: UL listed for applications where required by NFPA 13 and NFPA 14.
         a. Shutoff Duty: Use ball, butterfly (only as approved by Plant Operations), or gate valves.
      2. Unlisted General-Duty Valves: For applications where UL-listed valves are not required by NFPA 13 and NFPA 14.
         a. Shutoff Duty: Use ball, butterfly (only as approved by Plant Operations), or gate valves.

3.9 JOINT CONSTRUCTION
   A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic piping joint construction.
   B. Threaded Joints: Comply with NFPA 13 for pipe thickness and threads. Do not thread pipe smaller than NPS 8 with wall thickness less than Schedule 40 unless approved by authorities having jurisdiction and threads are checked by a ring gage and comply with ASME B1.20.1.
   C. Twist-Locket Joints: Insert plain-end piping into locking-lug fitting and rotate retainer lug one-quarter turn.
   D. Grooved Joints: Assemble joints with listed coupling and gasket, lubricant, and bolts.
2. Steel Pipe: Square-cut or roll-groove piping as indicated. Use grooved-end fittings and rigid, grooved-end-pipe couplings, unless otherwise indicated.
4. Dry-Pipe Systems: Use fittings and gaskets listed for dry pipe service.
5. Grooved joint piping systems shall be installed in accordance with the manufacturer’s guidelines and recommendations.
6. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by manufacturer.
7. Grooved end shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing.

E. Dissimilar-Metal Piping Joints: Construct joints using dielectric fittings compatible with both piping materials.
   1. NPS 2 and Smaller: Use dielectric unions, couplings, or nipples.
   2. NPS 2-1/2 to NPS 4: Use dielectric flanges.
   3. NPS 5 and Larger: Use dielectric flange insulation kits.

3.10 SERVICE-ENTRANCE PIPING
   A. Connect fire-suppression piping to water-service piping of size and in location indicated for service entrance to building. Refer to Division 22 Section "Facility Water Distribution Piping" for exterior piping.
   B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping. Refer to Division 22 Section "Facility Water Distribution Piping" for backflow preventers.
   C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.11 WATER-SUPPLY CONNECTION
   A. Connect fire-suppression piping to building's interior water distribution piping. Refer to Division 22 Section "Domestic Water Piping" for interior piping.
   B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water distribution piping. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers.
   C. Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

3.12 PIPING INSTALLATION
   A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic piping installation.
   B. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
      1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
   C. Install underground ductile-iron service-entrance piping according to NFPA 24 and with restrained joints. Encase piping in corrosion-protective encasement. Encasement shall be duct taped and fully sealed from water penetration.
D. Install underground copper service-entrance piping according to NFPA 24. Encase piping in corrosion-protective encasement.

E. Use approved fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

F. Install unions adjacent to each valve in pipes NPS 2 and smaller. Unions are not required on flanged devices or in piping installations using grooved joints.

G. Install flanges or flange adapters on valves, apparatus, and equipment having NPS 2-1/2 and larger connections.

H. Install "Inspector’s Test Connections" in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13.

I. Install sprinkler piping with drains for complete system drainage.

J. Provide stainless steel or chrome plated plastic, non-rusting escutcheons at all drain piping locations penetrating exterior walls. Refer to section 210500.

K. Install sprinkler zone control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

L. Install drain valves on standpipes.

M. Install ball drip valves to drain piping between fire department connections and check valves. Drain to floor drain or outside building.

N. Install alarm devices in piping systems.

O. Hangers and Supports: Comply with NFPA 13 for hanger materials.
   1. Install standpipe system piping according to NFPA 14 and the requirements of the Owners Insurance underwriter.
   2. Install sprinkler system piping according to NFPA 13, and the requirements of the Owners Insurance underwriter.
      a. Sprinkler system piping hangers and supports shall only support sprinkler and fire protection system components in compliance with NFPA 13-9.1.1.8.
      b. Sprinkler system piping shall be permitted to share support systems in compliance with NFPA 13-9.1.1.3.

P. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal-seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal and install where they will not be subject to freezing.

Q. Drain dry-type standpipe piping.

R. Drain dry-pipe sprinkler piping.

S. Pressurize and check dry-pipe sprinkler system piping and air compressors.

T. Fill wet-standpipe system piping with water.

U. Fill wet-pipe sprinkler system piping with water.

V. Install flexible connectors on fire-pump and pressure-maintenance-pump supply and discharge connections and in fire-suppression piping where indicated.

W. Pipe and fittings exposed to weather and piping between the check valve and fire department pumper connection shall be galvanized.

WATER-BASED FIRE-SUPPRESSION SYSTEMS

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3.13 VALVE INSTALLATION

A. Install listed fire-protection valves, unlisted general-duty valves, specialty valves and trim, controls, and specialties according to NFPA 13 and NFPA 14 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Valves for Wall-Type Fire Hydrants: Install nonrising-stem gate valve in water-supply pipe.

D. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water supply sources.

E. Specialty Valves:
   1. Alarm Check Valves: Install in vertical position for proper direction of flow, including bypass check valve and retarding chamber drain-line connection.
   2. Dry-Pipe Valves: Install trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
      a. Air-Pressure Maintenance Devices for Dry-Pipe Systems: Install shutoff valves to permit servicing without shutting down sprinkler system; bypass valve for quick system filling; pressure regulator or switch to maintain system pressure; strainer; pressure ratings with 60-psig with adjustable range; and 175-psig rated maximum inlet pressure.
      b. Install air compressor and compressed-air supply piping.
      c. Install compressed-air supply piping from building's compressed-air piping system.

3.14 SPRINKLER APPLICATIONS

A. Drawings indicate sprinkler types to be used. Where specific types are not indicated, use the following sprinkler types:
   1. Rooms without Ceilings: Upright sprinklers.
   2. Rooms with Suspended Ceilings: Concealed sprinklers
   4. Spaces Subject to Freezing: Pendent, dry sprinklers, Sidewall, dry sprinklers Upright, pendent, dry sprinklers; and sideway, dry sprinklers as indicated.
   5. Special Applications: Extended-coverage, flow-control, and quick-response sprinklers where indicated.
   6. Sprinkler Finishes:
      a. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.
      b. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
      c. Flush Sprinklers: Bright chrome, with painted white escutcheon.
      d. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
      e. Residential Sprinklers: Dull chrome.

3.15 EXCESS-PRESSURE PUMP INSTALLATION

A. Install excess-pressure pumps, controls, devices, and supports for wet-pipe sprinkler system application.
   1. Mounting: Install, where indicated.
3.16 SPRINKLER INSTALLATION
   A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels and tiles.
   B. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing. Use dry-type sprinklers with water supply from heated space.
   C. Sprinkler Guards shall be installed in all electric rooms, mechanical rooms, Tel/Data and IT rooms, elevator shafts, elevator machine rooms and computer rooms. Wire-cage type, including fastening device for attaching to sprinkler.
   D. Dry type, glass bulb type sprinklers shall not be installed in areas subject to freezing.
   E. The sprinkler bulb protector must remain in place until the sprinkler is completely installed and before the system is placed in service. Remove bulb protectors carefully by hand after installation. Do not use any tools to remove bulb protectors.
   F. For remodels:
      1. 15,000 SF and over: Provide spare sprinkler heads and head wrench per NFPA requirements.
      2. Under 15,000 SF: Match existing sprinkler heads in the immediate area.

3.17 HOSE-CONNECTION INSTALLATION
   A. Install hose connections adjacent to standpipes, unless otherwise indicated.
   B. Install freestanding hose connections for access and minimum passage restriction.
   C. Install NPS 2-1/2 hose connections with quick-disconnect NPS 2-1/2 by NPS 1-1/2 reducer adapter and flow-restricting device, unless otherwise indicated.
   D. Install wall-mounting-type hose connections in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Refer to Division 10 Section “Fire Extinguisher Cabinets” for cabinets.

3.18 HOSE-STATION INSTALLATION
   A. Install freestanding hose stations for access and minimum passage restriction.
   B. Install NPS 2-1/2 hose connections with quick-disconnect NPS 2-1/2 by NPS 1-1/2 reducer adapter and flow-restricting device, unless otherwise indicated.
   C. Install freestanding hose stations with support or bracket attached to standpipe or substrate.

3.19 MONITOR INSTALLATION
   A. Install monitor bases securely attached to building substrate.

3.20 FIRE HYDRANT INSTALLATION
   A. Install fire hydrants mounted in vertical wall with shutoff valve inside building in heated space.

3.21 FIRE DEPARTMENT CONNECTION INSTALLATION
   A. Install wall-type, fire department connections in vertical wall.
B. Install freestanding-type, fire department connections in level surface.
   1. Install protective pipe bollards on [two] [three] \textless Insert other arrangement\textgreater sides of each fire department connection. Refer to Division 05 Section "Metal Fabrications" for pipe bollards.

C. Install ball drip valve at each check valve for fire department connection.

3.22 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Connect water-supply piping to fire-suppression piping. Include backflow preventer between potable-water piping and fire-suppression piping. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers.

D. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.

E. Connect piping to specialty valves, hose valves, specialties, fire department connections, and accessories.

F. Connect excess-pressure pumps to the following piping and wiring:
   1. Sprinkler system, hydraulically.
   2. Pressure gages and controls, hydraulically.
   3. Electrical power system.
   4. Alarm device accessories for pump.
   5. Fire alarm.

G. Connect compressed-air supply to dry-pipe sprinkler piping.

H. Connect air compressor to the following piping and wiring:
   1. Pressure gages and controls.
   2. Electrical power system.
   3. Fire alarm devices, including low-pressure alarm.

I. Electrical Connections: Power wiring is specified in Division 26.

J. Connect alarm devices to fire alarm.

K. Ground equipment according to Division 26 Section "Grounding and Bonding."

L. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

M. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.23 LABELING AND IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and NFPA 14.
B. All valves on pipes of every description shall have neat circular brass valve tags of at least 1-1/2 inches in diameter, attached with brass hooks to each valve stem. Stamp on these valve tags in letters as large as practicable the number of the valve and the service and zone, such as "S.P.", "D", for standpipe, drain, respectively. The numbers of each service shall be consecutive.

C. These numbers shall correspond to numbers indicated for valves on the record drawings and on two printed detailed lists. These printed lists shall state the numbers and locations of each valve and the fixture or group of fixtures, which it controls, and other necessary information, such as requiring the opening or closing of another valve or valves, when any one valve is to be opened or closed.

D. These printed lists shall be typed and shall be framed under glass and mounted as directed by the Architect.

E. Copies of charts shall be included in O&M manuals.

3.24 FIELD QUALITY CONTROL.

A. This Contractor shall obtain and pay for all the inspections and tests required for this Section of the work. Defects discovered in work, materials and/or equipment shall be replaced at no cost to the Owner, and the inspection and test shall be repeated. When work is completed, this Contractor shall furnish a Certificate of Inspection and Approval to the Owner before final payment of the Contract will be allowed.

B. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   3. Energize circuits to electrical equipment and devices.
   4. Start and run excess-pressure pumps.
   5. Start and run air compressors.
   7. Flush, test, and inspect standpipe systems according to NFPA 14, "System Acceptance" Chapter.
   8. Coordinate with fire alarm tests. Operate as required.
   9. Coordinate with fire-pump tests. Operate as required.
   10. Verify that equipment hose threads are same as local fire department equipment.

C. Report test results promptly and in writing to Architect and authorities having jurisdiction.

3.25 CLEANING AND PROTECTION

A. After completion of the work, all tools and other equipment shall be removed from the building. All excess materials shall be removed and the building left broom clean. All cabinets, valves, and equipment shall be cleaned and polished.

B. This Contractor shall clean, patch and repair any material and finish of the building or its contents damaged during the execution of this Contract.

C. Clean dirt and debris from sprinklers.

D. Remove and replace sprinklers with paint other than factory finish.

E. Protect sprinklers from damage until Substantial Completion.
3.26 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves. Refer to Division 01 Section "Demonstration and Training."

B. A factory trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

3.27 INSPECTION SERVICE

A. After completion of the fire protection work and at start of the guarantee year, The Fire Protection Subcontractor shall execute the National Automatic Sprinkler and Fire Control Association, Inc. Standard Form of Inspection Agreement without charge to the Owner, calling for four (4) inspections of the system during the guarantee year. During the year, inspections shall be made as per the Inspection Agreement plus the following maintenance shall be performed on the last inspection:

1. Operation of all control valves.
2. Lubrication of stems of all control valves.
3. Operation of all alarms.
4. Cleaning of alarm valves and parts.

B. The standard form, "Report of Inspection" shall be filled out in triplicate after each inspection and copies sent to the Owner and the Owner's insuring agency.

C. All inspections and maintenance shall be in accordance with applicable NFPA Standards, including NFPA #25, as a minimum. Requirements of Owner's Insurance and other Authorities Having Jurisdictions are also a part of this service.

END OF SECTION 211000
WATER-BASED FIRE-SUPPRESSION SYSTEMS

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SECTION 213113 - ELECTRIC-DRIVE, CENTRIFUGAL FIRE PUMPS, CONTROLLERS AND MAINTENANCE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes electric-drive, [split-case] [end-suction] [in-line] centrifugal fire pumps and the following:
   1. Fire pump controllers and automatic transfer switches.
   2. Fire pump accessories and specialties.
   3. Pressure-maintenance pumps, controllers, accessories, and specialties.
   4. Alarm panels.
   5. Flowmeter systems.

1.2 PERFORMANCE REQUIREMENTS

A. Pump, Equipment, Accessory, Specialty, and Piping Pressure Rating: 175-psig minimum working-pressure rating, unless otherwise indicated.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Division 21 Section "Basic Division 21 Requirements."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, certified pump performance curves with each selection point indicated, operating characteristics, and furnished accessories and specialties for each fire pump and pressure-maintenance pump.

B. Certification Letter:
   1. Product Certificates: For each type of fire pump and fire pump controller, signed by product manufacturer.

C. Shop Drawings:
   1. For fire pumps and drivers, fire-pump controllers, fire-pump accessories and specialties, pressure-maintenance pumps, pressure-maintenance-pump controllers, and pressure-maintenance-pump accessories and specialties. Include plans, elevations, sections, details, and attachments to other work.
   2. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   4. The term "withstand" means, "The unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   5. The term "withstand" means, "The unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   6. Dimensioned Outline Drawings of Equipment Unit: Identify the center of gravity then locate and describe mounting and anchorage provisions.
7. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.5 INFORMATIONAL SUBMITTALS
A. Qualification Data:
   1. Source quality-control test reports.
   2. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For fire pumps and drivers, pressure-maintenance pumps, controllers, accessories and specialties, alarm panels, and flowmeter systems to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE
A. Source Limitations: Obtain fire pumps, pressure-maintenance pumps, and controllers through one source from a single manufacturer for each type of equipment.
B. Product Options: Drawings shall indicate the following: size, profiles, and dimensional requirements of fire pumps, pressure-maintenance pumps, and controllers and are based on specific systems indicated. Refer to Division 01 Section "Product Requirements."
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to Authorities Having Jurisdiction, and marked for intended use.
   1. Underwriters Laboratories (UL) listed and labeled.
D. Comply with standards of authorities having jurisdiction pertaining to materials, hose threads, and installation.

1.8 COORDINATION
A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS
2.1 MANUFACTURERS
A. Basis of Design: Per the manufacturer listed.
B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.
C. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CENTRIFUGAL FIRE PUMPS

A. Description, General: UL 448, factory-assembled and -tested, electric-drive, centrifugal fire pumps capable of furnishing not less than 150 percent of rated capacity at not less than 65 percent of total rated head and with shutoff head limited to 140 percent of total rated head.

1. Finish: Manufacturer's standard red paint applied to factory-assembled and -tested unit before shipping.

2. Nameplate: Complete with capacities, characteristics, and other pertinent data.

B. Single-Stage, Horizontally Mounted, Split-Case Fire Pumps: Double-suction type with pump and driver mounted on same base and connected with coupling.

1. Manufacturers:
   b. Armstrong Darling, Inc.
   c. Aurora Pump; Pentair Pump Group.
   d. Fairbanks Morse; Pentair Pump Group.
   e. Paco Pumps, Inc.
   f. Patterson Pump Company.
   g. Reddy-Buffaloes Pump Co.
   h. Sterling Peerless Pump; Sterling Fluid Systems Group.

2. Pump: Axially split cast-iron casing with suction and discharge flanges machined to ASME B16.1, Class 125 dimensions, unless otherwise indicated.
   a. Impeller: Cast bronze of construction to match fire pump, statically and dynamically balanced, and keyed to shaft.
   b. Wear Rings: Replaceable, bronze.
   c. Shaft and Sleeve: Steel shaft with bronze sleeve.
      1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
      2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.

3. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.

4. Driver: UL-listed, NEMA MG 1, open-dripproof, squirrel-cage, induction motor complying with NFPA 20 and NFPA 70. Include wiring compatible with controller used.
   a. Manufacturers:
      1) Emerson; U.S. Electrical Motors.
      2) Lincoln Electric Company (The).
      3) Marathon Electric, Inc.

C. Single-Stage, Vertically Mounted, Split-Case Fire Pumps: Double-suction type with pump mounted on baseplate and connected to driver with coupling.

1. Manufacturers:
b. Aurora Pump; Pentair Pump Group.
c. Patterson Pump Company.
d. Reddy-Buffaloes Pump Co.

2. Pump: Axially split cast-iron casing with suction and discharge flanges machined to ASME B16.1, Class 125 dimensions, unless otherwise indicated.
   a. Impeller: Cast bronze of construction to match fire pump, statically and dynamically balanced, and keyed to shaft.
   b. Wear Rings: Replaceable, bronze.
   c. Shaft and Sleeve: Steel shaft with bronze sleeve.
      1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
      2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.

3. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.

4. Driver: UL-listed, NEMA MG 1, open-dripproof, squirrel-cage, induction motor complying with NFPA 20 and NFPA 70. Include wiring compatible with controller used.
   a. Manufacturers:
      1) Emerson; U.S. Electrical Motors.
      2) Lincoln Electric Company (The).
      3) Marathon Electric, Inc.

D. Multistage, Horizontally Mounted, Split-Case Fire Pumps: Two-stage, single-suction type with pump and driver mounted on same base and connected with coupling.

1. Manufacturers:
   b. Armstrong Darling, Inc.
   c. Aurora Pump; Pentair Pump Group.
   d. Fairbanks Morse; Pentair Pump Group.
   e. Patterson Pump Company.
   g. Sterling Peerless Pump; Sterling Fluid Systems Group.

2. Pump: Axially split cast-iron casing with suction and discharge flanges machined to ASME B16.1, Class 125 dimensions, unless otherwise indicated.
   a. Impeller: Cast bronze of construction to match fire pump, statically and dynamically balanced, and keyed to shaft.
   b. Wear Rings: Replaceable, bronze.
   c. Shaft and Sleeve: Steel shaft with bronze sleeve.
      1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
      2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.

3. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.

4. Driver: UL-listed, NEMA MG 1, open-dripproof, squirrel-cage, induction motor complying with NFPA 20 and NFPA 70. Include wiring compatible with controller used.
E. End-Suction Fire Pumps: Single-stage, horizontally mounted type with driver mounted on same base and connected with coupling.

1. Manufacturers:
   b. Armstrong Darling, Inc.
   c. Patterson Pump Company.
   d. Reddy-Buffaloes Pump Co.
   e. Sterling Peerless Pump; Sterling Fluid Systems Group.

2. Pump: Radially split cast-iron casing with suction and discharge flanges machined to ASME B16.1, Class 125 dimensions, unless otherwise indicated.
   a. Impeller: Cast bronze of construction to match fire pump, statically and dynamically balanced, and keyed to shaft.
   b. Wear Rings: Replaceable, bronze.
   c. Shaft and Sleeve: Steel shaft with bronze sleeve.
      1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
      2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.

3. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.

4. Driver: UL-listed, NEMA MG 1, open-dripproof, squirrel-cage, induction motor complying with NFPA 20 and NFPA 70. Include wiring compatible with controller used.
   a. Manufacturers:
      1) Emerson; U.S. Electrical Motors.
      2) Lincoln Electric Company (The).
      3) Marathon Electric, Inc.
b. Wear Rings: Replaceable, bronze.
c. Shaft and Sleeve: Steel shaft with bronze sleeve.
   1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
   2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.

3. Driver: UL-listed, NEMA MG 1, open-dripproof, squirrel-cage, induction motor complying with NFPA 20 and NFPA 70. Include wiring compatible with controller used.
   a. Manufacturers:
      1) Emerson; U.S. Electrical Motors.
      2) Lincoln Electric Company (The).
      3) Marathon Electric, Inc.

G. Fire-Pump Characteristics and Specialty Data:
   1. Fire-Pump Plan No.: <Insert designation used on Drawings.>
      a. Rated Capacity: <Insert value.>
      b. Total Rated Head: <Insert value.>
      c. Inlet Size: <Insert value.>
      d. Outlet Size: <Insert value.>
      e. Outlet Flange Class: [125] [250].
   2. Speed: Same as driver.
   3. Electric-Motor Driver: <Insert value> hp, [1750] [3500] <Insert other> rpm, 3 phase, 60 Hz.
      a. Full-Load Amperes: <Insert value.>
      b. Minimum Circuit Ampacity: <Insert value.>
      c. Maximum Overcurrent Protection: <Insert value.>
      d. Voltage: <Insert value.>
   4. Test Header Size: <Insert value.>
      a. Hose Valves Required: [One] [Two] [Three] [Four] [Six] [Eight] <Insert other>.
      b. Hose Valve Size: [NPS 1-1/2] [NPS 2-1/2]].
   5. Relief Valve Size: <Insert value.>
   6. Cone Size: <Insert value.>

2.3 FIRE-PUMP CONTROLLERS
   A. Fire-Pump Controllers, General: UL 218, NFPA 20, NFPA 70, and NFPA 110; listed for electric-drive, fire-pump service and service entrance; combined automatic and manual operation; factory assembled and wired; and factory tested for capacities and electrical characteristics.
      1. Manufacturers:
         b. Firetrol, Inc.
         c. Hubbell Industrial Controls, Inc.
         d. Joslyn Clark.
         e. Master Control Systems, Inc.
         f. Metron, Inc.
2. Rate controllers for scheduled fire-pump horsepower and short-circuit withstand rating at least equal to short-circuit current available at controller location. Take into account cable size and distance from substation, supply transformers, or generator(s).

3. Enclosure: UL 50, Type 2, dripproof, indoor, unless special-purpose enclosure is indicated. Include manufacturer’s standard red paint applied to factory-assembled and -tested unit before shipping.

4. Controls, devices, alarms, functions, and operations listed in NFPA 20 and NFPA 70 as required for drivers and controller types used, and specific items listed.
   a. Isolating means and circuit breaker.
   b. "Power on" pilot lamp.
   c. Fire alarm system contacts for indicating motor running condition, loss-of-line power, and line-power phase reversal or dead phase condition.
   d. Automatic and manual operation, minimum run-time relay to prevent short cycling.
   e. Water-pressure-actuated switch with independent high and low calibrated adjustments responsive to water pressure in fire-suppression piping.
   f. Automatic and manual shutdown.
   g. System pressure recorder, electric ac driven with spring backup.

5. Nameplate: Complete with capacity, characteristics, approvals and listings, and other pertinent data. Include specific data as required by NFPA 70.

6. Controller Sensing Pipes: Fabricate pipe and fittings according to NFPA 20 with nonferrous-metal sensing piping, NPS 1/2, with globe valves for testing controller mechanism from system to pump controller as indicated. Include bronze check valve with 3/32-inch orifice in clapper or ground-face union with noncorrosive diaphragm having 3/32-inch orifice.

B. Fire Pump Controllers:
   1. Type Starting: Electrical starting requirements can significantly impact the generator sizing criteria.
      a. Autotransformer (closed transition) reduced voltage starter.
      b. Part winding (closed transition) reduced voltage starter.
      c. Wye-delta, closed transition, reduced voltage starter.
   3. Automatic Transfer Switches: UL 218 and UL 1008 and requirements for and attached to fire-pump controllers. Include enclosure complying with UL 50, Type 2, with automatic transfer switch with continuous rating at least 125 percent of fire-pump driver-motor horsepower. Include ampere rating not less than 125 percent of motor full-load current and suitable for switching motor-locked rotor current. Provide withstand rating equal or greater than upstream device rating.

C. Limited Service Fire Pump Controllers:
   1. Type Starting: Across the line.

2.4 FIRE-PUMP ACCESSORIES AND SPECIALTIES
A. Match fire-pump suction and discharge ratings as required for fire-pump capacity rating. Include the following:
   2. Circulation relief valve.
3. Suction and discharge pressure gages.
4. Eccentric-tapered reducer at suction inlet.
5. Concentric-tapered reducer at discharge outlet.
6. Test-Header Manifold: Ductile-iron or brass body for hose valves. Include nozzle outlets arranged in single line; horizontal, flush-wall mounting attachment; and rectangular, [polished chrome-plated] [rough] brass finish escutcheon plate with lettering equivalent to "PUMP TEST CONNECTION."
7. Test-Header Manifold: Ferrous body for hose valves. Manufacturer's standard finish. Include bronze or cast-iron, exposed-type valve header with nozzle outlets; and round, brass escutcheon plate with lettering equivalent to "PUMP TEST CONNECTION."
8. Hose Valves: UL 668, straightway pattern, and bronze with cap and chain. Include NFPA 1963 hose thread that complies with local fire department standards and finish same as for test-header-manifold escutcheon plate.
10. Main Relief Valve: UL 1478, [pilot operated] [spring loaded].
11. Discharge Cone: [Closed] [Open] type.
12. Finish: Manufacturer's standard factory-applied red paint unless brass or other finish is specified.
13. Electrical Accessories:
   a. Sequential start time on-delay relay.
   b. Minimum run time delay relay.
   c. Off-delay time delay relay.
   d. Testing interval time delay relay.
   e. Operator interface/user keypad.
   f. Ammeter/voltmeter.
   g. Alarm annunciator (LCD type).
   h. Data logging/event recording function.
   i. Solid-state pressure transducer plus digital display for system pressure.

2.5 PRESSURE-MAINTENANCE PUMPS

A. Pressure-Maintenance Pumps, General: Factory-assembled and -tested pumps with electric-motor driver, controller, and accessories and specialties. Include cast-iron or stainless steel casing and bronze or stainless-steel impellers, mechanical seals, and suction and discharge flanges machined to ASME B16.1, Class 125 dimensions unless Class 250 flanges are indicated and except that connections may be threaded in sizes where flanges are not available.

   1. Finish: Manufacturer's standard color paint applied to factory-assembled and -tested unit before shipping.
   2. Nameplate: Complete with capacity, characteristics, and other pertinent data.

B. Multistage, Pressure-Maintenance Pumps: Multiple-impeller type complying with HI 1.1-1.2 and HI 1.3 requirements for multistage centrifugal pumps. Include base.

   1. Manufacturers:
      b. Grundfos Pumps Corp.
      c. Jacuzzi Brothers.
      d. Paco Pumps, Inc.
      e. Sterling Peerless Pump; Sterling Fluid Systems Group.
      f. Taco, Inc.
2. Driver: NEMA MG 1, open-dripproof, squirrel-cage, induction motor complying with NFPA 20 and NFPA 70. Include wiring compatible with controller used.

C. Regenerative-Turbine, Pressure-Maintenance Pumps: Close-coupled type complying with HI 1.1-1.2 and HI 1.3 requirements for regenerative-turbine centrifugal pumps. Include base.
   1. Manufacturers:
      a. Aurora Pump; Pentair Pump Group.
      b. Crane Pumps & Systems, Inc.
      c. Fairbanks Morse; Pentair Pump Group.
      d. MTH Tool Co., Inc.
      e. Paco Pumps, Inc.
   2. Driver: NEMA MG 1, open-dripproof, squirrel-cage, induction motor complying with NFPA 20 and NFPA 70. Include wiring compatible with controller used.

D. Controllers: UL 508; factory-assembled, -wired, and -tested, across-the-line type for combined automatic and manual operation.
   1. Manufacturers:
      b. Firetrol, Inc.
      c. Hubbell Industrial Controls, Inc.
      d. Joslyn Clark.
      e. Master Control Systems, Inc.
      f. Metron, Inc.
   2. Enclosure: UL 508 and NEMA 250, Type 2, wall-mounting type for field electrical wiring.
      a. Finish: Manufacturer's standard color paint applied to factory-assembled and -tested unit before shipping.
   3. Rate controller for scheduled horsepower and include the following:
      a. Fusible disconnect switch.
      b. Pressure switch.
      c. Hand-off-auto selector switch.
      d. Pilot light.
      e. Running period timer.

E. Accessories and Specialties: Match pressure-maintenance-pump suction and discharge ratings as required for pump capacity rating. Include the following:
   2. Suction and discharge pressure gages.

F. Pressure-Maintenance-Pump Characteristics and Specialty Data:
   1. Plan No.: [Insert designation used on Drawings.]
   2. Rated Capacity: [Insert value.]
   3. Total Rated Head: [Insert value.]
   4. Pump Speed: [1750] [3500] rpm.
      a. Horsepower: [Insert value.]
      b. Full-Load Amperes: [Insert value.]

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ELECTRIC-DRIVE, CENTRIFUGAL FIRE PUMPS, CONTROLLERS AND MAINTENANCE PUMPS 213113 - 9

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c. Minimum Circuit Ampacity: <Insert value.>

d. Maximum Overcurrent Protection: <Insert value.>

e. Voltage: <Insert value.>

2.6 ALARM PANELS

A. Description: Factory-assembled and -wired remote panel complying with UL 508 and requirements in NFPA 20. Include audible and visible alarms matching controller type.

1. Manufacturers:
   b. Firetrol, Inc.
   c. Hubbell Industrial Controls, Inc.
   d. Joslyn Clark.
   e. Master Control Systems, Inc.
   f. Metron, Inc.

2. Enclosure: NEMA 250, Type 2, remote wall-mounting type.
   a. Finish: Manufacturer's standard red paint applied to factory-assembled and -tested unit before shipping.

3. Features: Include manufacturer's standard features and the following:
   a. Motor-operating condition.
   b. Loss-of-line power.
   c. Phase reversal.
   d. Low-water alarm.
   e. Form C auxiliary Contacts for remote monitoring:
      1) Fire pump running.
      2) Fire pump power failure.
      3) Fire pump dead phase or phase-reversal condition.

2.7 FLOWMETER SYSTEMS

A. Description: Fire-pump flowmeter system that indicates flow to not less than 175 percent of fire-pump rated capacity. Include sensor of size to match pipe, tubing, flowmeter, and fittings.

1. Approved Manufacturers:
   a. Dieterich Standard Inc.
   b. Gerand Engineering Co.
   c. Hyspan Precision Products, Inc.
   d. Meriam Instruments Div.; Scott Fetzer Co.
   e. Preso Meters Corporation.
   g. Fire Research Corp.


3. Sensor: Venturi, annubar probe, or orifice plate, unless otherwise indicated.

4. Flowmeter: Compatible with flow sensor with dial not less than 4-1/2 inches in diameter or manufacturer's equivalent size.

5. Permanently Mounted Flowmeter: Suitable for wall mounting with copper tubing to connect to flow sensor.

2.8 PRESSURE GAGES
A. Description: UL 393, 3-1/2- to 4-1/2-inch-diameter dial with range of [0- to 250-psig] [0- to 300-psig] minimum. Include caption "WATER" on dial face.
   1. Manufacturers:
      a. AGF Manufacturing Co.
      b. AMETEK, Inc.; U.S. Gauge.
      c. Brecco Corporation.
      d. Dresser Equipment Group; Instruments Div.
      e. Marsh Bellofram.
      f. WIKA Instrument Corporation.

2.9 GROUT
A. Description: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.

2.10 SOURCE QUALITY CONTROL
A. Test and inspect fire pumps with their controllers according to NFPA 20 for certified shop tests.
B. Verification of Performance: Rate fire pumps according to requirements indicated.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine areas, concrete bases, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of fire pumps.
B. Examine roughing-in for fire-suppression piping to verify actual locations of piping connections before fire-pump installation.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES
A. Install concrete bases of dimensions indicated for fire pumps, pressure-maintenance pumps, and controllers. Refer to Division 21 Section "Common Work Results for Fire Suppression."
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported equipment.
B. Cast-in-place concrete materials and placement requirements are specified in Division 03.
3.3 INSTALLATION

A. Install and align fire pump, pressure-maintenance pump, and controller according to NFPA 20.

B. Install pumps and controllers to provide access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Set base-mounted-type pumps on concrete bases. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.
   1. Support pump baseplate on rectangular metal blocks and shims or on metal wedges having small taper, at points near anchor bolts, to provide 3/4- to 1-1/2-inch gap between pump base and concrete base for grouting.
   2. Adjust metal supports or wedges until pump and driver shafts are level. Verify that coupling faces and pump suction and discharge flanges are level and plumb.

D. Install suction and discharge piping equal to or greater than diameter of fire-pump nozzles.

E. Install valves that are same size as piping connecting fire pumps, bypasses, test headers, and other piping systems.

F. Install pressure gages on fire-pump suction and discharge at pressure-gage tappings.

G. Support pumps and piping separately so weight of piping does not rest on pumps.

H. Install piping accessories, hangers and supports, anchors, valves, meters and gages, and equipment supports.

I. Install flowmeters and sensors where indicated. Install flowmeter-system components and make connections according to manufacturer's written instructions.

J. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

3.4 ALIGNMENT

A. Align [split-case] [end-suction] fire-pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.

B. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.

C. Align piping connections.

D. Align pump and driver shafts for angular and parallel alignment according to HI 1.4 and to tolerances specified by manufacturer.

E. Align vertically mounted, split-case pump and driver shafts after complete unit has been made plumb on concrete base, grout has set, and anchor bolts have been tightened.

3.5 POWER WIRING INSTALLATION

A. Install power wiring between controllers and their services or sources, and between controllers and their drivers. Comply with requirements in NFPA 20, NFPA 70, and Division 26 Section "Low Voltage Electrical Power Conductors and Cables."
B. The starting method specified herein utilizes (3) output phase conductors from the controller to fire pump as a basis of design; selection of any reduced voltage starter that required (6) output phase conductors to the fire pump will require this Division to pay for the additional materials and labor installation costs by Division 26.

3.6 CONNECTIONS

A. Piping installation requirements are specified in Division 21 Section "Water-Based Fire-Suppression Systems." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps and equipment to allow service and maintenance.

C. Connect water supply and discharge piping to fire pumps [with flexible connectors]. Connect water supply and discharge piping to pressure-maintenance pumps [with flexible connectors]. [Refer to Division 21 Section "Water-Based Fire-Suppression Systems" for flexible connectors.]

D. Connect relief-valve discharge to point of disposal.

E. Connect flowmeter-system sensors and meters according to manufacturer's written instructions.

F. Connect controllers to pumps.

G. Connect fire-pump controllers to building fire-alarm system. Refer to Division 28 Section "Fire Detection and Alarm."

H. Ground equipment according to Division 26 Section "Grounding and Bonding."

I. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform field tests for each fire pump when installation is complete. Comply with operating instructions and procedures in NFPA 20 and NFPA 70 to demonstrate compliance with requirements. Where possible, field correct malfunctioning equipment, and then retest to demonstrate compliance. Replace equipment that cannot be satisfactorily corrected or that does not perform as indicated, and then retest to demonstrate compliance. Verify that each fire pump performs as indicated.

C. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Final Checks before Startup: Perform the following preventive-maintenance operations and checks:
      a. Lubricate oil-lubrication-type bearings.
      b. Remove grease-lubrication-type bearing covers, flush bearings with kerosene, and clean thoroughly. Fill with new lubricant according to manufacturer's written instructions.
      c. Disconnect coupling and check electric motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.
3. Starting procedure for pumps is as follows:
   a. Prime pump by opening suction valve and closing drains, and prepare pump for operation.
   b. Open sealing-liquid supply valves if pump is so fitted.
   c. Start motor.
   d. Open discharge valve slowly.
   e. Observe leakage from stuffing boxes and adjust sealing-liquid valve for proper flow to ensure lubrication of packing. Do not tighten gland immediately, but let packing run in before reducing leakage through stuffing boxes.
   f. Check general mechanical operation of pump and motor.
   g. Check and record motor amperage for no load and full load conditions.

4. Test and adjust controls and safety. Replace damaged and malfunctioning controls and equipment. Record all protective device settings and time delay durations.

5. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Fire hoses are for field-acceptance tests only and are not property of Owner.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire pumps, drivers, controllers, and pressure-maintenance pumps. Provide basic tutorial on operation and maintenance; explain each control and device indication, and submit to Owner. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 213113
SECTION 220500 - BASIC DIVISION 22 REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Piping materials and installation instructions common to most piping systems.
   2. Transition fittings.
   3. Dielectric fittings.
   4. Mechanical sleeve seals.
   5. Sleeves.
   6. Core Drilling
   7. Escutcheons.
   8. Grout.
  10. Painting and finishing.
  11. Supports and anchorages.

1.2 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, and spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
F. The following are industry abbreviations for plastic materials:
   1. CPVC: Chlorinated polyvinyl chloride plastic.
   2. PE: Polyethylene plastic.
   3. PVC: Polyvinyl chloride plastic.
G. The following are industry abbreviations for rubber materials:
   1. EPDM: Ethylene-propylene-diene terpolymer rubber.
   2. NBR: Acrylonitrile-butadiene rubber.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Division 22 Section "Basic Division 22 Requirements."
1.4 ACTION SUBMITTALS
A. Product Data: For the following:
   1. Transition fittings.
   2. Dielectric fittings.
   3. Mechanical sleeve seals.
   4. Escutcheons.

1.5 QUALITY ASSURANCE
A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code—Steel."
B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
C. Cast Iron Soil Pipe: Pipe and fittings shall be marked with the collective trademark of the cast iron soil pipe institute or receive prior approval of the engineer.
D. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING
A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION
A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.
B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

1.8 OWNER REVIEW OF INSTALLATION
A. At substantial completion, Contractor will schedule a walk-through with Owner to review locations and accessibility of items requiring routine maintenance and access. Items found to be inaccessible shall be relocated to area acceptable to Owner at no cost to Owner.
PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Basis of Design: Per the manufacturer listed.
B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.
C. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS
A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.
B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS
A. Refer to individual Division 22 piping Sections for special joining materials not listed below.
B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   2. AWWA C110, rubber, flat face, 1/8-inch-thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
H. Solvent Cements for Joining Plastic Piping:
   1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
2.4 PRESS FITTINGS

A. Copper Press-Connect Fittings:
   1. Manufacturers:
      a. Viega LLC
      b. NIBCO Inc.
   2. For Types K, L, and M hard copper tubing 1/2 inch to 4 inch and soft copper tubing in 1/2 inch to 1-1/4 inch.
   3. Housing: Copper or bronze.
   4. Smart Connect Feature.
   5. Sealing Element: EPDM.
   6. Tools: Manufacturer's special tools.
   7. Maximum 200-psig working-pressure rating at 250° F.

B. Di-Electric Union with Press-Connect Fittings.
   1. Manufacturers:
      a. Viega LLC
      b. NIBCO INC.
   2. For Types K, L, and M: Hard Copper Tubing in 1/2 inch to 2 inch and Soft Copper Tubing in 1/2 inch to 1-1/4 inch.
   3. Galvanized metal Female NPT threaded connection.
   4. Gasket: EPDM.
   5. Electrical conductivity separation ring.
   7. Sealing Element: EPDM
   8. Tools: Manufacturer's special tools.
   9. Maximum, 200-psig working pressure rating at 250° F.

C. Cast Copper Alloy Pipe Flanges with Press-Connect Fittings.
   1. Manufacturers:
      a. Viega LLC
      b. NIBCO INC.
   2. For Types K, L, and M hard copper tubing 1/2 inch to 4 inch and soft copper tubing in 1 inch to 1-1/4 inch.
   4. Flanges: CLASS 150 Powder Coated Steel Plate two-piece design for potable water applications.
   5. Housing: Copper or bronze.
   6. Smart Connect.

2.5 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
   1. Manufacturers:
      b. Dresser Industries, Inc.; DMD Div.
      c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.

BASIC DIVISION 22 REQUIREMENTS

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2. Aboveground Pressure Piping: Pipe fitting.

B. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Manufacturers:
   a. Eslon Thermoplastics.
   b. NIBCO
   c. Spears Manufacturing

C. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Manufacturers:
   a. Thompson Plastics, Inc.
   b. NIBCO
   c. Spears Manufacturing

D. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.

1. Manufacturers:
   a. NIBCO, Inc.
   b. NIBCO, Inc.; Chemtrol Div.

2.6 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180° F.

1. Manufacturers:
   a. Capitol Manufacturing Co.
   b. Central Plastics Company.
   c. Eclipse, Inc.
   d. Epco Sales, Inc.
   g. Zurn Industries, Inc.; Wilkins Div.
D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
   1. Manufacturers:
      a. Capitol Manufacturing Co.
      b. Central Plastics Company.
      c. Epco Sales, Inc.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   1. Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Central Plastics Company.
      d. Pipeline Seal and Insulator, Inc.
   2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225° F.
   1. Manufacturers:
      a. Calpico, Inc.
      b. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225° F.
   1. Manufacturers:
      a. Perfection Corp.
      b. Precision Plumbing Products, Inc.
      c. Sioux Chief Manufacturing Co., Inc.
      d. Victaulic Co. of America.

2.7 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   1. Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Link-Seal.
      d. Metraflex Co.
      e. Pipeline Seal and Insulator, Inc.
   2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   3. Pressure Plates: Plastic. Include two for each sealing element.
   4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

BASIC DIVISION 22 REQUIREMENTS
2.8 SLEEVES
A. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
B. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
C. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with set screws.
D. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
F. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.9 ESCUTCHEONS
A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
B. One-Piece, Cast-Brass Type: With polished, chrome-plated and rough-brass finish and setscrew fastener.
C. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
D. Split-Casting Brass Type: With polished, chrome-plated and rough-brass finish and with concealed hinge and setscrew.
E. One-Piece, Stamped-Steel Type: With set screw and chrome-plated finish.
F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw, and chrome-plated finish.

2.10 GROUT
A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION
3.1 PLUMBING DEMOLITION
A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.
B. Disconnect, demolish, and remove plumbing systems, equipment, and components where indicated to be removed.
   1. Piping to Be Removed: Remove portion of piping indicated to be removed back to main and cap and add isolation valve on piping 1-inch and larger.
   2. Equipment to Be Removed: Disconnect and cap services and remove equipment.
3. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.

4. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality. A maximum of 5'-0" in all directions from point of connection. Prior to any work the owner or owner’s representative shall be notified and shown the damaged area.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install exposed piping and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise on the Drawings.

E. Install piping above accessible ceilings to allow enough space for ceiling panel removal.

F. Exposed supply and drainage piping at equipment and plumbing fixtures shall be chrome plated.

G. The plumbing contractor shall not install "PVC" piping or components in any areas or spaces that are intended to serve as a return air plenum. All systems installed within a return air plenum shall be rated for that particular application.

H. Install piping to permit valve servicing.

I. Install piping at indicated slopes.

J. Install piping free of sags and bends.

K. Install fittings for changes in direction and branch connections.

L. Install piping to allow application of insulation.

M. Select system components with pressure rating equal to or greater than system operating pressure.

N. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type with spring clips.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
e. Bare Piping in Unfinished Service Spaces: Split-casting brass type with polished, chrome-plated finish.
f. Bare Piping in Equipment Rooms: Split-casting brass type with rough-brass finish.
g. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

2. Existing Piping: Use the following:
   a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
   b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge and spring clips.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   d. Bare Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated finish.
   e. Bare Piping in Equipment Rooms: Split-casting brass type with rough-brass finish.
   f. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

O. Sleeves are not required for core-drilled holes.

P. Permanent sleeves are not required for holes formed by removable PE sleeves.

Q. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

R. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
   3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
      a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
      b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
      c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
         1) Seal space outside of sleeve fittings with grout.
   4. Seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

S. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
   1. Install steel pipe for sleeves smaller than 6 inches in diameter.
   2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.

BASIC DIVISION 22 REQUIREMENTS

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3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

T. On all metal sleeves with flanges, apply a weld bead where the flange meets the longitudinal axis of the sleeve.

U. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

2. On walls 12 inches and larger, provide a second mechanical seal on the exterior and one on the interior side of the wall.

V. Fire-BARRIER Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

W. Verify final equipment locations for roughing-in.

X. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 CORE DRILLING

A. Perform all core drilling required for the installation of the plumbing systems. Locate all required openings and prior to coring coordinate the opening with the Construction Manager. Thoroughly investigate the existing conditions in the vicinity of the required opening prior to coring. Care must be taken so as not to disturb the existing building systems. Locate all other openings required for the Construction Manager. Patching of existing walls and openings shall be performed by the respective Trade responsible for the finish material in which the opening is made.

B. Before coring is performed, submit drawings showing location of cores to structural engineers for their review.

3.4 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.


F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Cast iron soil piping for above ground applications shall be fabricated with heavy duty no-hub clamps. Cast iron piping underground shall be hub and spigot type with neoprene gasket.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
   3. PVC Nonpressure Piping: Join according to ASTM D 2855.

J. Press-Connected Joints for Copper Tubing: Join copper tube and press-connect fittings with tools recommended by fitting manufacturer.

K. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

L. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

M. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
   1. Plain-End Pipe and Fittings: Use butt fusion.
   2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.5 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
   1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
   3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
3.6 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS
   A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
   B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
   C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
   D. Install equipment to allow right of way for piping installed at required slope.
   E. The plumbing contractor shall provide all required water and drainage connections to allow for the proper installation and operation of the Owner’s equipment. The plumbing contractor shall review the equipment information prior to installing the systems to serve that equipment.

3.7 PAINTING
   A. Painting of plumbing systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."
   B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES
   A. Refer to Division 05 Section "Metal Fabrications" for structural steel.
   B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

3.9 ERECTION OF WOOD SUPPORTS AND ANCHORAGES
   A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.
   B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
   C. Attach to substrates as required to support applied loads.

3.10 GROUTING
   A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
   B. Clean surfaces that will come into contact with grout.
   C. Provide forms as required for placement of grout.
   D. Avoid air entrapment during placement of grout.
   E. Place grout, completely filling equipment bases.
   F. Place grout on concrete bases and provide smooth bearing surface for equipment.
G. Place grout around anchors.
H. Cure placed grout.

3.11 Owner Furnished Equipment
   A. Refer to Division 01

END OF SECTION 220500
PART 1 - GENERAL

1.1 SUMMARY
A. Section Includes:
   1. Thermometers.
   2. Thermowells.
   4. Test plugs.
B. Related Sections:
   1. Division 22 Section "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.

1.2 DEFINITIONS
A. CR: Chlorosulfonated polyethylene synthetic rubber.
B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 22 Section "Basic Division 22 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product indicated; include performance curves.
B. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Basis of Design: Per the manufacturer listed.
B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

2.2 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Palmer - Wahl Instruments, Inc.
   2. Trerice, H. O. Co.
   3. Weiss Instruments, Inc.
   4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
B. Case: Die-cast aluminum or brass, 9 inches long.
C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.
D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.

E. Window: Glass or plastic.

F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

I. Basis of design is Trerice Model BX9

2.3 LIGHT-ACTIVATED THERMOMETERS

A. Direct-Mounted, Light-Activated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. REOTEMP Instrument Corporation.
   b. Trerice, H.O. Co.
   c. Weiss Instruments, Inc.
   d. WIKA Instrument Corporation – USA
   e. Winters Instruments – U.S.

B. Case: Waterproof NEMA 4X with cast Aluminum

C. Scale(s): Degrees F and Degrees C.

D. Case Form: 7” adjustable angle.

E. Connector: 1-1/4 inches, with ASME B1.1 screw thread.

F. Stem: Aluminum and of length to suit installation.

1. Design for Thermowell Installation: Bare stem.

G. Display: Digital

H. Accuracy: Plus or minus 1-degree F.

I. Basis of design is Trerice Model SX9 Solar Therm

2.4 THERMOWELLS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AMETEK, Inc.; U.S. Gauge Div.
3. Ernst Gage Co.
5. Miljoco Corp.
6. NAMMAC Corporation.
7. Noshok, Inc.
8. Palmer - Wahl Instruments, Inc.
9. REO TEMP Instrument Corporation.
10. Tel-Tru Manufacturing Company.
11. Trerice, H. O. Co.
12. Weiss Instruments, Inc.
13. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
14. WIKA Instrument Corporation.
15. Winters Instruments.

B. Manufacturers: Same as manufacturer of thermometer being used.

C. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

1. Material: Brass, for use in copper piping.
4. Insertion Length: To extend to center of pipe.
5. Cap: Threaded, with chain permanently fastened to socket.
6. Heat-Transfer Fluid: Oil or graphite.

2.5 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AMETEK, Inc.; U.S. Gauge Div.
3. Ernst Gage Co.
4. Eugene Ernst Products Co.
5. KOBOLD Instruments, Inc.
7. Miljoco Corp.
8. Noshok, Inc.
10. REO TEMP Instrument Corporation.
11. Trerice, H. O. Co.
12. Weiss Instruments, Inc.
13. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
14. WIKA Instrument Corporation.
15. Winters Instruments.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.

1. Case: Dry type, drawn steel or cast aluminum 4-inch diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Pointer: Red or another dark-color metal.
7. Window: Glass or plastic.
9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

C. Pressure-Gage Fittings:
   1. Valves: NPS 1/4 brass or stainless steel needle type.
   2. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.6 TEST PLUGS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Flow Design, Inc.
      2. MG Piping Products Co.
      4. Peterson Equipment Co., Inc.
      5. Sisco Manufacturing Co.
      6. Trerice, H. O. Co.
   B. Description: Corrosion-resistant brass or stainless steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.
   C. Minimum Pressure and Temperature Rating: 500 psig at 200°F.
   D. Core Inserts: One or two self-sealing rubber valves.
      1. Insert material for water service at 20 to 200°F shall be CR.
      2. Insert material for water service at minus 30 to plus 275°F shall be EPDM.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS
   A. Install liquid-in-glass, direct-mounting, thermometers where indicated on the Drawings.
   B. Provide the following temperature ranges for thermometers:
      1. Domestic Hot Water: 30 to 180°F, with 2-degree scale divisions for standard water temperatures. High temperature systems: 30 to 240°F, with 2-degree scale divisions for high temperature supply such as to kitchens.
      2. Domestic Cold Water: 30 to 130°F, with 2-degree scale divisions.

3.2 GAGE APPLICATIONS
   A. Install dry-case-type pressure gages where indicated on the Drawings.

3.3 INSTALLATIONS
   A. Install direct-mounting thermometers and adjust vertical and tilted positions.
   B. Install separable sockets in vertical position with socket extending to center of pipe in piping tees where fixed thermometers are indicated. If caps are specified, fill sockets with oil or graphite and secure caps.
   C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.
D. Install needle valve and snubber fitting in piping for each pressure gage.
E. Install test plugs in tees in piping.
F. Install flow indicators, in accessible positions for easy viewing, in piping systems.
G. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters as prescribed by manufacturer's written instructions.
H. Install flowmeter elements in accessible positions in piping systems.
I. Install thermometers and gages adjacent to machines and equipment to allow service and maintenance for thermometers, gages, machines, and equipment.
J. Adjust faces of thermometers and gages to proper angle for best visibility.

END OF SECTION 220519
SECTION 220523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following general-duty valves:
   1. Copper-alloy ball valves.
   2. Ferrous-alloy butterfly valves.
   4. Spring-loaded, lift-disc check valves.
   5. Gate valves.
   6. Chain wheel actuators.

B. Related Sections include the following:
   1. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and charts.

1.2 DEFINITIONS

A. The following are standard abbreviations for valves:
   1. CWP: Cold working pressure.
   2. EPDM: Ethylene-propylene-diene terpolymer rubber.
   3. NBR: Acrylonitrile-butadiene rubber.
   4. PTFE: Polytetrafluoroethylene plastic.
   5. TFE: Tetrafluoroethylene plastic.

1.3 SUBMITTALS

A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.4 QUALITY ASSURANCE

A. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

B. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service. All domestic water valves shall meet these standards.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set gate valves closed.
   4. Set ball and plug valves open to minimize exposure of functional surfaces.
   5. Set butterfly valves closed or slightly open.
   6. Block check valves in either closed or open position.
B. Use the following precautions during storage:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Basis of Design: Per the manufacturer listed.
   B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.
   C. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
      1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 VALVES, GENERAL
   A. Refer to Part 3 "Valve Applications" Article for applications of valves.
   B. Bronze Valves: NPS 2 and smaller with pressed ends, unless otherwise indicated.
   C. Ferrous Valves: NPS 2-1/2 and larger with flanged ends, unless otherwise indicated.
   D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
   E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.
   F. Valve Actuators:
      1. Lever Handle: For quarter-turn valves NPS 6 and smaller, except plug valves.
      2. Wrench: For plug valves with square heads. Furnish Owner with one (1) wrench for every 10 plug valves, for each size square plug head.
   G. Valve Stems on insulated piping: Taper the insulation to allow full range of movement of valves and handles. No valve stem extensions permitted.
   I. Valve Grooved Ends: AWWA C606.
   J. Solder Joint: With sockets according to ASME B16.18.
      1. Caution: Use solder with melting point below 840 deg F for angle, check, and gate valves; below 421 deg F for ball valves.
   L. Valve Bypass and Drain Connections: MSS SP-45.

GENERAL DUTY VALVES FOR PLUMBING PIPING
2.3 COPPER-ALLOY BALL VALVES

A. Manufacturers:
   1. Two-Piece, Copper-Alloy Ball Valves:
      b. Grinnell Corporation.
      c. Milwaukee Valve Company.
      d. NIBCO, INC.
      e. Viega.

B. Copper-Alloy Ball Valves, General: MSS SP-110. Sweat or pressed ends.

C. Two-Piece, Copper-Alloy Ball Valves: Bronze, lead free, dezincification resistant body with full-port, stainless steel ball; PTFE seats; and 200-psig minimum CWP rating and blowout-proof stem.

2.4 FERROUS-ALLOY BUTTERFLY VALVES

A. Manufacturers:
   1. Flange Style, Ferrous-Alloy Butterfly Valves:
      a. Grinnell Corporation.
      b. Milwaukee Valve Company.
      c. NIBCO, INC.

B. Ferrous-Alloy Butterfly Valves, General: MSS SP-67, Type I, for tight shutoff, with disc and lining suitable for potable water, unless otherwise indicated.

C. Flanged, 150-psig CWP Rating, Ferrous-Alloy Butterfly Valves: Flanged-end type with one-piece stem.

2.5 BRONZE CHECK VALVES

A. Manufacturers:
   1. Bronze, Swing Check Valves with Nonmetallic Disc:
      a. Apollo Valves.
      b. Conbraco Valves.
      c. Grinnell Corporation.
      d. Milwaukee Valve Company.
      e. NIBCO, INC.

B. Bronze Check Valves, General: MSS SP-80.

C. Type 2, Class 125, Bronze, Horizontal Lift Check Valves: Bronze body with nonmetallic disc and bronze seat.

D. Type 2, Class 125, Bronze, Vertical Lift Check Valves: Bronze body with nonmetallic disc and bronze seat.

E. Type 2, Class 150, Bronze, Horizontal Lift Check Valves: Bronze body with nonmetallic disc and bronze seat.
F. Type 3, Class 125, Bronze, Swing Check Valves: Bronze body with bronze disc and seat.

G. Type 3, Class 150, Bronze, Swing Check Valves: Bronze body with bronze disc and seat.

H. Type 3, Class 200, Bronze, Swing Check Valves: Bronze body with bronze disc and seat.

I. Type 4, Class 125, Bronze, Swing Check Valves: Bronze body with nonmetallic disc and bronze seat.

J. Type 4, Class 150, Bronze, Swing Check Valves: Bronze body with nonmetallic disc and bronze seat.

K. Type 4, Class 200, Bronze, Swing Check Valves: Bronze body with nonmetallic disc and bronze seat.

2.6 SPRING-LOADED, LIFT-DISC CHECK VALVES

A. Manufacturers:

1. Type I, Wafer Lift-Disc Check Valves:
   a. Mueller Steam Specialty.

2. Type II, Compact-Wafer, Lift-Disc Check Valves:
   a. Durabla Fluid Technology, Inc.
   b. Flomatic Valves.
   c. GA Industries, Inc.
   d. Grinnell Corporation.
   e. Metraflex Co.
   f. Milwaukee Valve Company.
   g. Mueller Steam Specialty.
   h. Multiplex Manufacturing Co.
   i. NIBCO, INC.
   j. SSI Equipment, Inc.
   l. Valve and Primer Corp.

3. Type III, Globe Lift-Disc Check Valves:
   a. Durabla Fluid Technology, Inc.
   b. Flomatic Valves.
   c. GA Industries, Inc.
   d. Grinnell Corporation.
   e. Metraflex Co.
   f. Milwaukee Valve Company.
   g. Multiplex Manufacturing Co.
   h. NIBCO, INC.
   i. SSI Equipment, Inc.
   k. Valve and Primer Corp.

4. Type IV, Threaded Lift-Disc Check Valves:
   a. Check-All Valve Mfg. Co.
   b. Durabla Fluid Technology, Inc.
   c. Grinnell Corporation.
   d. Legend Valve & Fitting, Inc.
   e. Metraflex Co.
f. Milwaukee Valve Company.
g. Mueller Steam Specialty.
h. NIBCO, INC.
i. Watts Industries, Inc.; Water Products Div.

B. Lift-Disc Check Valves, General: FCI 74-1, with spring-loaded bronze or alloy disc and bronze or alloy seat.

C. Type IV, Class 125, Threaded Lift-Disc Check Valves: Threaded style with bronze shell and press ends.

D. Type IV, Class 150, Threaded Lift-Disc Check Valves: Threaded style with bronze shell and press ends.

2.7 CAST-IRON PLUG VALVES

A. Manufacturers:

1. Nonlubricated-Type, Cast-Iron Plug Valves:
   a. General Signal; DeZurik Unit.
   b. Grinnell Corporation.
   e. Wheatley Gaso, Inc.
   f. Xomox Corporation.

B. Cast-Iron Plug Valves, General: MSS SP-78.

C. Class 125 or 150, nonlubricated-type, cast-iron plug valves.

D. Class 250, non-lubricated-type, cast-iron plug valves.

E. All plug valves shall be epoxy coated for all parts to come in contact with water and shall meet NSF 61 requirements.

2.8 GATE VALVES

A. Gate Valves, Bronze, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo.
   b. Milwaukee Valve Company.
   c. NIBCO, INC.

2. Description:
   b. CWP Rating: 300 psig.
   d. Ends: Flanged or pressed.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable or ductile iron.
2.9  CHAINWHEEL ACTUATORS

A.  Manufacturers:
   1.  Babbitt Steam Specialty Co.
   2.  Roto Hammer Industries, Inc.

B.  Description: Valve actuation assembly with sprocket rim, brackets, and chain.
   1.  Sprocket Rim with Chain Guides: Ductile iron of type and size required for valve. Include zinc coating.
   2.  Brackets: Type, number, size, and fasteners required to mount actuator on valve.
   3.  Chain: Stainless steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1  EXAMINATION

A.  Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.
   1.  Proceed with installation only after unsatisfactory conditions have been corrected.

B.  Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C.  Operate valves in positions from fully open to fully close. Examine guides and seats made accessible by such operations.

D.  Examine threads on valve and mating pipe for form and cleanliness.

E.  Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

F.  Do not attempt to repair defective valves; replace with new valves.

3.2  VALVE APPLICATIONS

A.  Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:
   1.  Shutoff Service: Ball or butterfly, gate or plug valves.
   2.  Throttling Service: Ball, butterfly, gate valves.

B.  If valves with specified CWP ratings are not available, the same types of valves with higher CWP ratings may be substituted.

C.  Domestic Water Piping: Use the following types of valves:
   2.  Ball Valves, NPS 2-1/2 and Larger: Class [150] [300], ferrous alloy.
   4.  Swing Check Valves, NPS 2 and Smaller: Type 4, Class 125, bronze.
   5.  Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
6. Plug Valves, NPS 2 and Larger: Class 125 or 150, cast iron.
7. Resilient-Seated, Eccentric Plug Valves, NPS 3 and Larger: 175-psig CWP rating, cast iron.

D. Sanitary Waste and Storm Drainage Piping: Use the following types of valves:
1. Ball Valves, NPS 2 and Smaller: Three-piece, 400-psig (2760-kPa) CWP rating, copper alloy.
2. Ball Valves, NPS 2-1/2 and Larger: Class 150, ferrous alloy.
3. Swing Check Valves, NPS 2 and Smaller: Type [3] [4], Class [125] [150], bronze.
4. Swing Check Valves, NPS 2-1/2 and Larger: Type [I] [II], Class 125, gray iron.
5. Grooved-End, Ductile-Iron, Swing Check Valves, NPS 2-1/2 (DN 65) and Larger: 175-psig (1207-kPa) minimum CWP rating.
6. Gate Valves, NPS 2-1/2 and Larger: Type I, Class 125, [NRS] [OS&Y], bronze-mounted cast iron.
7. Plug Valves, NPS 2 and Larger: Class 125 or 150, non-lubricated type, cast iron.

E. Select valves, except wafer and flangeless types, with the following end connections:
1. For Copper Tubing, NPS 2 and Smaller: Solder-joint or pressed ends.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged or pressed ends.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.

3.3 VALVE INSTALLATION
A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
C. Locate valves for easy access and provide separate support where necessary.
D. Install valves in horizontal piping with stem at or above center of pipe.
E. Install valves in position to allow full stem movement.
F. Install chain wheel operators on valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor elevation.
G. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Dual-Plate Check Valves: In horizontal or vertical position, between flanges.

3.4 JOINT CONSTRUCTION
A. Refer to Division 22 Section "Basic Division 22 Requirements" for basic piping joint construction.
B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.
3.5 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

END OF SECTION 220523
SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes the following hangers and supports for plumbing system piping and equipment:
      1. Steel pipe hangers and supports.
      2. Trapeze pipe hangers.
      3. Metal framing systems.
      4. Pipe stands.
   B. Related Sections include the following:
      1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
      2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-suppression piping.
      3. Division 22 Section "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.

1.2 DEFINITIONS
   A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry, Inc.
   B. NPS: Nominal Pipe Size.
   C. DN: Nominal Diameter.

1.3 PERFORMANCE REQUIREMENTS
   A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
   B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
   C. Loads applied to structure are not to exceed the allowable loads listed on the structural drawings.

1.4 SUBMITTALS
   A. General: Submit the following in accordance with Division 22 Section "Basic Division 22 Requirements."

1.5 ACTION SUBMITTALS
   A. Product Data: For the following:
      1. Steel pipe hangers and supports.
      2. Thermal-hanger shield inserts.
   B. Shop Drawings:
      1. Trapeze pipe hangers. Include Product Data for components.
      2. Metal framing systems. Include Product Data for components.
3. Pipe stands. Include Product Data for components.
4. Equipment supports.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to the following:
1. AWS D1.1, "Structural Welding Code – Steel."
2. AWS D1.2, "Structural Welding Code – Aluminum."
4. ASME Boiler and Pressure Vessel Code: Section IX.

B. UL Compliance: Provide products that are UL listed.

C. MSS Standard Compliance:
1. Provide pipe hangers and supports of which materials, design and manufacture comply with MSS SP-58.
2. Select and apply pipe hangers and supports, complying with MSS SP-69.
3. Fabricate and install pipe hangers and supports, complying with MSS SP-89.
4. Terminology used in this section is defined in MSS SP-90.

1.7 CODES AND STANDARDS

A. All materials and workmanship described herein shall be in accordance with the latest editions and addenda of the codes and standards listed below and all Federal, State and local codes. Should there be any conflict between any codes, standard, and/or specification, the more stringent shall govern.
1. ASME American Society of Mechanical Engineers
2. ASTM American Society for Testing and Materials
3. AWS American Welding Society
4. MFMA Metal Framing Manufacturers Association
5. MSS Manufacturer Standardization Society of the Valve and Fitting Industry
6. NEMA National Electrical Manufacturers Association
7. NFPA National Fire Protection Association
8. IAPMO International Association of Plumbing and Mechanical Officials
9. SSPC The Society for Protective Coatings (formerly Steel Structures Painting Council)
10. UL Underwriters Laboratories

B. Standards:
1. ASME B31.9 Building Services Piping
2. ASTM A 36/A 36M Specification for Carbon Structural Steel
3. ASTM A 780 Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
4. ASTM C 533 Specification for Calcium Silicate Block and Pipe Thermal Insulation
5. ASTM C 552 Specification for Cellular Glass Thermal Insulation
6. ASTM C 1107 Specification for Packaged Dry, Hydraulic-Cement grout (Nonshrink)
7. IAPMO PS 42 Pipe Alignment & Secondary Support Systems
8. MFMA-3 Metal Framing Standards Publication
9. MFMA-102 Guidelines for the Use of Metal Framing
10. MSS SP-58 Materials Design and Manufacturing
11. MSS SP-69 Selection and Application
12. MSS SP-89 Fabrication and Installation Practices
13. MSS SP-90  Guidelines on Terminology for Pipe Hangers and Supports
14. SSPC-PA 1  Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel

1.8 BUILDING ATTACHMENTS

A. Steel Frame Structures: In general, attach all piping work to building steel. Install intermediate support steel between building steel if support between beams or joists is required.

1. Where composite floor slab is present, drilled-in-wedge-type expansion anchors may be used in locations approved by Architect. If use of expansion anchors is proposed, submit for approval by Architect, locations, load and attachment details. All anchor materials to be used shall be as specified in specification sections pertaining to building structure and as approved by the Architect (powder actuated inserts shall not be used).

B. Concrete Frame Structures: In general, attach all mechanical work to building structure utilizing either cast-in-place inserts or drilled-in-wedge expansion anchors. Submit for approval by Architect, locations, loads and attachment details for all mechanical work. All anchor materials to be used shall be as specified in specification sections pertaining to building structure and as approved by the Architect (powder actuated inserts shall not be used).

1. If cast-in-place inserts are proposed, provide building attachment submittal data with structural concrete reinforcement shop drawings.

C. Concrete Frame Structures: In general, attach all mechanical work to building structure utilizing screw anchors. Submit for approval by Architect, locations, loads, and attachment details for all mechanical work. All anchor materials to be used shall be as specified in specification sections pertaining to building structure and as approved by the Architect.

PART 2 - PRODUCTS

2.1 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Galvanized, Metallic Coatings: Pre-galvanized or hot dipped.

C. Nonmetallic Coatings: Plastic coating, jacket, or liner.

D. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.

C. Nonmetallic Coatings: Plastic coating, jacket, or liner.
2.4 FASTENER SYSTEMS
   A. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened Portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   B. Screw Anchors: Pre-drilling of the holes requires a standard ANSI drill bit with the same diameter as the anchor and installation will be done with an impact wrench. Provide carbon steel anchors with zinc plating.

2.5 EQUIPMENT SUPPORTS
   A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.6 MISCELLANEOUS MATERIALS
   A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
   B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
      2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION
3.1 HANGER AND SUPPORT APPLICATIONS
   A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
   B. Comply with MSS SP-69 for pipe hanger, selections and applications, that are not specified in piping system Sections.
   C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
   D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
   E. Use padded hangers for piping that is subject to scratching.
   F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
      1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
      2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
      3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
      4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
      5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
      6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
10. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
11. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
12. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
13. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
14. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
15. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500), if longer ends are required for riser clamps.

H. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large. Consult project structural engineer for this condition prior to any installation.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to the flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads. Consult project structural engineer for this condition prior to any installation.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions. Consult project structural engineer for this condition prior to any installation.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
a. Light (MSS Type 31): 750 lb.
b. Medium (MSS Type 32): 1500 lb.
c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

I. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
   2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
   3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

J. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
   2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
   3. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.

K. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

L. Comply with MFMA-102 for metal framing system, selections and applications, that are not specified in piping system Sections.

M. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

3.2 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

D. Pipe Stand Installation:
   1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.

E. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.


G. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

H. Install lateral bracing with pipe hangers and supports to prevent swaying.

I. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 < and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

J. Load Distribution: Install hangers and supports so piping of live and dead loads and stresses from movement will not be transmitted to connected equipment.

K. Pipe Slopes: Install hangers and supports at indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.

L. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating Below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   3. Shield Dimensions for Pipe:
      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
      b. NPS 4: 12 inches long and 0.06 inch thick.
      c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   5. Insert Material: Length at least as long as protective shield.

M. Hanger Spacing Schedule:
   1. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
      a. NPS 1 and Smaller: 72 inches with 3/8-inch rod.
      b. NPS 1-1/4 – NPS 3: 10 feet with 1/2-inch rod.
      c. NPS 4 and Larger: 10 feet with 5/8-inch rod.
   2. Install supports for vertical steel piping every 10 feet.
   3. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
a. NPS 1 and Smaller: 72 inches with 3/8-inch rod.
b. NPS 1-1/4 and Larger: 10 feet with ½-inch rod.

4. Install supports for vertical copper tubing every 10 feet.

5. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
   b. NPS 3 and 4: 48 inches with 3/8-inch rod.
   c. NPS 5: 48 inches with 5/8-inch rod.
   d. NPS 6: 48 inches with 3/4-inch rod.
   e. NPS 8 to NPS 12: 48 inches with 7/8-inch rod.

6. Install supports for vertical PVC piping every 48 inches.

7. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 1 and Smaller: 72 inches with 3/8-inch rod.
   b. NPS 1-1/4 and NPS 4: 10 feet with ½-inch rod.
   c. NPS 6 and Larger: 10 feet with 5/8-inch rod.

8. Install supports for vertical stainless steel piping every 10 feet.

3.3 EQUIPMENT SUPPORTS

   A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
   B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
   C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

   A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
   B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
   C. Field Welding: Comply with AWS D1.1 procedure for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
      1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
      2. Obtain fusion without undercut or overlap.
      3. Remove welding flux immediately.
      4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

   A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
   B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.
3.6 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 Section "High-Performance Coatings."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 220529
SECTION 220533 - HEAT TRACING FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes plumbing piping heat tracing for freeze prevention, with the following electric heating cables:
   1. Self-regulating, parallel resistance. Best option needs to be in the plumbing but must be controlled by electrical.

B. Related Sections include the following:
   1. Division 23 Section "Heat Tracing for HVAC Piping."

C. Plumbing contractor to furnish and install heat tracing system in its entirety and by retaining a qualified electrical contractor to install all electrical connections.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 22 Section "Basic Division 22 Requirements."

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
   1. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

B. Shop Drawings: For electric heating cable.
   1. Layout Drawings:
      a. Include plans, sections, details, and attachments to other work.
      b. Wiring Diagrams: Power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:
   1. For electric heating cables to include in operation and maintenance manuals.
   2. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to Authorities Having Jurisdiction, and marked for intended use.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.
   1. Warranty Period: 10 years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Basis of Design: Per the manufacturer listed.
B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

2.2 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Chromalox, Inc.; Wiegard Industrial Division; Emerson Electric Company.
2. Delta-Therm Corporation.
4. Raychem; a division of Tyco Thermal Controls.
5. Thermon Manufacturing Co.
6. Trasor Corp.
B. Heating Element: Pair of parallel No. 16 AWG, nickel-coated stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled nonheating leads with connectors at one end and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.
C. Electrical Insulating Jacket: Flame-retardant polyolefin.
D. Cable Cover: Polyolefin outer jacket with UV inhibitor.
E. Maximum Operating Temperature (Power On): 150°F.
F. Maximum Exposure Temperature (Power Off): 185°F.
G. Maximum Operating Temperature: 300°F.
H. Capacities and Characteristics:
1. Maximum Heat Output: All heat trace to have 5 W/ft output unless otherwise noted on drawings. Greater outputs require approval of Owner.
2. Piping Diameter: <Insert NPS.>
3. Number of Parallel Cables: <Insert number.>
5. Volts: [120] [208] [240] [277] [480] V.
6. Phase: <Insert value.>
10. Maximum Overcurrent Protection: <Insert value.>

2.3 CONTROLS
A. Pipe-Mounting Thermostats for Freeze Protection:
1. Remote bulb unit with adjustable temperature range from 30 to 50°F.
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
3. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.

B. Monitor and control of heat tracing to be connected from the heat tracing control panel into the Building Automation System (BACNET).
   1. Loss of power (alarm).
   2. Failure to activate (alarm).
   3. Heat trace on/off (monitor).
   4. Fluid temperature through immersion temperature probe (alarm if fluid drops 5 deg. F below heat trace temperature after initial heat-up).

2.4 ACCESSORIES
A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.
B. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
   2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION
3.1 EXAMINATION
A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.
   1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
   2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS
A. Install the following types of electric heating cable for the applications described:
   1. Snow and Ice Melting on Roofs and in Gutters and Downspouts: Add all storm piping in non-heated areas. Self-regulating, parallel-resistance heating cable.

3.3 INSTALLATION
A. Install electric heating cable across expansion, construction, and control joints according to manufacturer’s written recommendations using cable protection conduit and slack cable to allow movement without damage to cable.
B. Electric Heating Cable Installation for Snow and Ice Melting on Roofs and in Gutters and Downspouts: Install on roof and in gutters and downspouts with clips furnished by manufacturer that are compatible with roof, gutters, and downspouts.
C. Electric Heating Cable Installation for Freeze Protection for Piping:
1. Install electric heating cables after piping has been tested and before insulation is installed.
2. Install electric heating cables according to IEEE 515.1.
3. Install insulation over piping with electric cables according to Division 22 Section "Plumbing Insulation."
4. Install warning tape on piping insulation where piping is equipped with electric heating cables.

D. Set field-adjustable switches and circuit-breaker trip ranges.
E. Protect installed heating cables, including nonheating leads, from damage.

3.4 CONNECTIONS
A. Ground equipment according to Division 26 Section "Grounding and Bonding."
B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
C. Connect the heat tracing system to the building automation system.

3.5 FIELD QUALITY CONTROL
A. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
   1. Test cables for electrical continuity and insulation integrity before energizing.
   2. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.
B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounting cables.
C. Remove and replace malfunctioning units and retest as specified above.
D. Test all signals to and from the building automation system.

END OF SECTION 220533
SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY
   A. Section Includes:
      1. Equipment labels.
      2. Warning signs and labels.
      3. Pipe labels.
      4. Valve labels.
      5. Warning tags.

1.2 SUBMITTALS
   A. General: Submit the following in accordance with Division 22 Section "Basic Division 22 Requirements."

1.3 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Samples: For color, letter style, and graphic representation required for each identification material and device.
   C. Shop Drawings:
      1. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
      2. Valve numbering scheme.

1.4 CLOSEOUT SUBMITTALS
   A. Operations and Maintenance Data:
      1. Valve Schedules: For each piping system to include in maintenance manuals.

1.5 COORDINATION
   A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
   B. Coordinate installation of identifying devices with locations of access panels and doors.
   C. Install identifying devices before installing acoustical ceilings and similar concealment.

1.6 QUALITY ASSURANCE
   A. Codes and Standards:
      1. ANSI Standards: Comply with (ASME) ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.
1.7 CODES AND STANDARDS

A. All materials and workmanship described herein shall be in accordance with the latest editions and addenda of the codes and standards listed below and all Federal, State and local codes. Should there be any conflict between any codes, standard, and/or specification, the more stringent shall govern.

1. ASME – American Society of Mechanical Engineers.

B. Standards:


PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 4 by 1 inch.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's unique equipment number. See sample 2.1E below.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number. Equipment schedule shall be included in operation and maintenance data.

D. Equipment Schedule: (With some examples that have been used)

<table>
<thead>
<tr>
<th>IDENTIFICATION SCHEDULE</th>
<th>SECTION 220553</th>
</tr>
</thead>
<tbody>
<tr>
<td>EQUIPMENT</td>
<td>IDENTIFICATION</td>
</tr>
<tr>
<td>Domestic Water Heater</td>
<td>DHW–HX–CFAC–PK2-1,2/M-1,2,3</td>
</tr>
<tr>
<td>Domestic Hot Water Storage Tank</td>
<td>ST-CFAC-PK2-1/M-1</td>
</tr>
<tr>
<td>Sanitary Sump</td>
<td>SE-CFAC-PK3-1</td>
</tr>
</tbody>
</table>

IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT 220553 - 2

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<table>
<thead>
<tr>
<th>IDENTIFICATION SCHEDULE</th>
<th>SECTION 220553</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storm Sump</td>
<td>SP-CFAC-PK3-1</td>
</tr>
<tr>
<td>Sanitary Sump Control Panel</td>
<td>SECP-CFAC-PK3-1</td>
</tr>
<tr>
<td>Storm Sump Control Panel</td>
<td>SPCP-CFAC-PK3-1</td>
</tr>
<tr>
<td>Chlorine Injection System</td>
<td>CI-CFAC-PK2-1</td>
</tr>
<tr>
<td>Environmental Services (Mop Basin)</td>
<td>NOTICE</td>
</tr>
<tr>
<td></td>
<td>ONLY USE HOSE BIBB FOR ENVIRONMENTAL SERVICES</td>
</tr>
<tr>
<td>Garage Hose Bibbs</td>
<td>NOTICE</td>
</tr>
<tr>
<td></td>
<td>NONPOTABLE WATER NOT TO BE USED FOR DRINKING</td>
</tr>
<tr>
<td>Preheat Heat Exchanger</td>
<td>PH-DWH-HX-CFAC-PK2-1/M-1</td>
</tr>
<tr>
<td>Heat Traced Panel</td>
<td>HTP-structure-level-01</td>
</tr>
<tr>
<td>Domestic Booster Pump</td>
<td>BP-CFAC-PK2-1</td>
</tr>
<tr>
<td>Elevator Sump Pit</td>
<td>ESP-CFAC-PK3-1</td>
</tr>
<tr>
<td>Re-Circulation Pump</td>
<td>RCP-CFAC-PK2-1/M-1</td>
</tr>
<tr>
<td>Pressure Tank</td>
<td>PT-CFAC-M-1</td>
</tr>
<tr>
<td>Thermostatic Mixing Valve</td>
<td>TMV-CFAC-PK2-1/M-1</td>
</tr>
</tbody>
</table>

NOTES
1. Mount on front 60” above finish door.
2. See detail 2.1 E for sample, follow sequence numbering if more than one schedule.
3. Mount on panel.
4. Mount on wall above Hose Bibb.
5. Mount on wall +/- 60 AFF.
6. Mount on wall above unit.
7. Mount on Unit.
E. Equipment Labels Example:

2.2 WARNING SIGNS AND LABELS
A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
B. Letter Color: Black.
C. Background Color: Yellow.
D. Maximum Temperature: Able to withstand temperatures up to 160° F.
E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
G. Fasteners: Stainless-steel rivets or self-tapping screws.
H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS
A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
D. Pipe Label Contents: Include identification of piping service, pipe size, and an arrow indicating flow direction.
1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction. Arrow direction labels are to be applied completely around the entire pipe regardless of the pipe size.
2. Lettering Size: At least 1-1/2 inches high.
### PIPE IDENTIFICATION SCHEDULE

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>BAND COLOR</th>
<th>TEXT COLOR</th>
<th>TAGGING SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Cold Water</td>
<td>Green</td>
<td>White</td>
<td>¾” – 1-1/4” 8” 1/2”</td>
</tr>
<tr>
<td>Domestic Hot Water</td>
<td>Yellow</td>
<td>Black</td>
<td>1-1/2” – 2” 8” 3/4”</td>
</tr>
<tr>
<td>Domestic Hot Water Return</td>
<td>Yellow</td>
<td>Black</td>
<td>2-1/2” – 6” 12” 1-1/4”</td>
</tr>
<tr>
<td>Domestic Tempered Water</td>
<td>Green</td>
<td>White</td>
<td>8”-10” 24” 2-1/2”</td>
</tr>
<tr>
<td>Sanitary Sewer</td>
<td>Green</td>
<td>White</td>
<td>Over 10” 32” 3-1/2”</td>
</tr>
<tr>
<td>Sanitary Vent</td>
<td>Green</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Storm Sewer</td>
<td>Green</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Clear Water Waste</td>
<td>Green</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Clear Water Waste Vent</td>
<td>Green</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Compressed Air</td>
<td>Blue</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Non Potable Cold Water</td>
<td>Yellow</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>Garage Waste</td>
<td>Yellow</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>Emergency Overflow Drain</td>
<td>Green</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Medical Air</td>
<td>Yellow</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>Medical Vacuum</td>
<td>White</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>Blue</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>Black</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>Gray</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Waste Anesthetic Gas Disposal</td>
<td>Purple</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Oxygen</td>
<td>Green</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Laboratory Air</td>
<td>Yellow/White Checker</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>Laboratory Vent</td>
<td>Green</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Laboratory Vacuum</td>
<td>Black/White Checker</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>Deionized Water</td>
<td>Green</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Reverse Osmosis</td>
<td>Green</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>City Water</td>
<td>Green</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Yellow</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>Heat Traced Piping</td>
<td>Yellow</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>Pumped Sanitary</td>
<td>Green</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Pumped Storm</td>
<td>Green</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Pumped Clear Water Waste</td>
<td>Green</td>
<td>White</td>
<td></td>
</tr>
</tbody>
</table>

**LOCATE PIPE IDENTIFICATION AS FOLLOWS:**

1. Within 1’-6” of each valve.
2. Within 3’-0” of each 90-degree elbow, connection to equipment or vessels, point where pipe enters shafts or penetrates outside walls.
3. On not over 20'-0" intervals along all piping (exposed and concealed).
4. At tees within 3'-0" of both main and branch.
5. For areas of multiple 90-degree elbows or tees consult project engineer for placement.
6. Where new piping meets existing, place one additional label on existing piping as specified in items 1 through 5.
7. Install buried pipe labels continuous and 12" below finished grade.
8. Install "NON-POTABLE" labels within 3'-0" downstream of backflow preventer.
9. Stenciling will not be allowed.
10. Minimum of one identification tag per room.

2.4 VALVE TAGS
   A. Valve Tags: Engraved with 1/4-inch letters for year, piping system abbreviation and building/floor/room numbers.
      1. Tag Material: Provide manufacturer’s standard solid brass valve tags with engraved lettering and having predrilled or stamped holes for attachment hardware.
         a. Include a factory applied blank white sticker on back of tag.
      2. Fasteners: Brass wire-link or beaded chain; or S-hook.
   B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
      1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS
   A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
      1. Size: 3 by 5-1/4 inches minimum.
      2. Fasteners: Brass grommet and wire.
      3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

PART 3 - EXECUTION

3.1 PREPARATION
   A. Clean piping and equipment surface of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION
   A. Install or permanently fasten labels on each major item of mechanical equipment.
   B. Locate equipment labels where accessible and visible.
3.3 PIPE LABEL INSTALLATION
   A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations per schedule.

3.4 VALVE-TAG INSTALLATION
   A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
   B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
      1. Valve-Tag Size and Shape:
         a. Cold Water: 2 inches or larger, round.
         b. Hot Water: 2 inches or larger, round.
         c. Compressed Air: 2 inches or larger, square.

<table>
<thead>
<tr>
<th>VALVE TAG SCHEDULE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SERVICE</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

3.5 WARNING-TAG INSTALLATION
   A. Write required message on, and attach warning tags to, equipment and other items where required.

3.6 ADJUSTING
   A. Relocate mechanical identification materials and devices that have become visually blocked by work of this or other Divisions.

3.7 CLEANING
   A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION 220553
SECTION 220700 - PLUMBING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Insulation Materials:
      a. Cellular glass.
      b. Glass wool fiber.
   2. Adhesives.
   3. Mastics.
   4. Lagging adhesives.
   5. Sealants.
   6. Tapes.
   7. Securements.
   8. Corner angles.

B. Related Sections include the following:

1.2 REFERENCE STANDARDS

A. ASTM International (ASTM).
B. American Society of Heating, Refrigerating, and air Conditioning Engineers, Inc. (ASHRAE).
C. North American Insulation Manufacturers Association (NAIMA).
D. National Fire Protection Association (NFPA).
E. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA).
F. Underwriter's Laboratories (UL).
G. Underwriter's Laboratories Environmental (UL Environment).

1.3 DEFINITIONS

A. Thermal Conductivity (K value): Units of Btu-inch/hour per square foot per degree F.
B. UL GREENGUARD: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic compounds (VOC's), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by EPA, OSHA and WHO.
C. EPA: Environmental Protection Agency.
D. WHO: World Health Organization.
E. ASJ+: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a Kraft paper interleafing with an outer film layer leaving no paper exposed.
F. ASJ: All Service Jacket (no outer film).
G. SSL+: Self-Sealing Lap with Advanced Closure System.
H. SSL: Self-Sealing Lap.
I. FKS: foil Scrim Kraft; jacketing.
J. PSK: Poly Scrim Kraft; jacketing.

K. PVC: Polyvinyl chloride.

L. Glass Wool: Interchangeable with fiber glass but replacing the term in the attempt to disassociate and differentiate glass mineral wool from the potential health and safety of special purpose or reinforcement products that do not meet the bio-solubility criteria of insulation made from glass. Rock mineral wool will replace the traditional mineral wool label. Both are used in lieu of the mineral fiber label.

M. UL Environment Formaldehyde Free Verification Requirements: For a product to be verified as formaldehyde free, product samples must have a measured emission factor of less than or equal to 5 µg/m²h at 24 elapsed hours or 3 µg/m²h at 336 elapsed hours. An emission factor of 5 µg/m²h corresponds to measured chamber concentration of 2.5 µg/m³ for a typical building ratio of 0.5 m²/m³. This chamber concentration is comparable to, or below typical outdoor air concentrations. This demonstrates that the formaldehyde exposure from products labeled as formaldehyde free will not contribute to airborne formaldehyde concentrations at greater levels than those found in the natural outdoor environment.

1.4 SUBMITTAL

A. General: Submit the following in accordance with Division 22 Section "Basic Division 22 Requirements."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. Sustainability/Sustainable Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.

2. Product Data for Credit MR 5 Regional Materials: For products and materials to comply with requirements for regional materials, provide documentation indicating location of product or material manufacturing location and the point of extraction, harvest, or recovery for each raw material. Include distance to project, contractor cost for each regional material and percent by weight that is considered regional.

3. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that product complies with the testing and product requirements of the California Department of Health Services’ “Standard Practice for the Testing of volatile Organic Emissions from various Sources Using Small-Scale Environment chambers”.

C. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

2. Detail attachment and covering of heat tracing inside insulation.

3. Detail insulation application at pipe expansion joints for each type of insulation.

4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
1.6 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: Insulation and related materials UL/ULC Classified per UL 723 or meeting ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

B. Formaldehyde Free: Third party certified with UL Environment Validation.

C. Bio-soluble: As determined by research conducted by the International Agency for Research on Cancer (IARC) and supported by revised reports from the national Toxicology Program (NTP) and the California Office of Environmental Health Hazard Assessment. Certified by European Certification Board for Mineral Wool Products (EUCEB).

D. Recycled Content: A minimum of 50 percent post-consumer recycled glass content certified, and UL validated.

E. Low Emitting Materials: For all thermal and acoustical applications of glass mineral wool insulation products, provide materials complying with the testing and products requirements to UL GREENGUARD Gold Certification.


G. Environmental Product Declarations (EPD) certified by a third party agency.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.8 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 Section "Hangers and Supports."

B. Coordinate clearance requirements with piping Installer for piping insulation application and equipment Installer for equipment insulation application. Before preparing piping, Shop Drawings establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.9 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.
PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Basis of Design: Per the manufacturer listed.
   B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

2.2 INSULATION MATERIALS
   A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
   B. Products shall not contain formaldehyde, asbestos, lead, mercury, or mercury compounds if possible. Products shall be certified UL GREENGUARD Gold or Indoor Advantage Gold.
   C. Insulation materials applied to carbon steel shall be Mass Load Corrosion Rate (MLCR) tested per ASTM 1617.
   D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
   E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
   F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Pittsburgh Corning Corporation; Foamless Super K.
      2. Block Insulation: ASTM C 552, Type I.
      3. Special-Shaped Insulation: ASTM C 552, Type III.
      4. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2. Cellular glass is NOT preformed. It is fabricated from block form into pipe and shapes by a fabrication.
      5. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
   G. Glass Wool, Preformed Pipe Insulation:

      1. Products: Subject to compliance with requirements, provide one of the following:
         a. Knauf Insulation; Earthwool 1000° pipe insulation with ECOSE technology.
         b. Knauf Insulation; Earthwool Redi-Klad 1000° pipe insulation with ECOSE technology.
         c. Manson Insulation Alley-K.
         d. Johns Manville; Micro-Lok.
         e. Owens Corning; Fiberglas Pipe Insulation.

      2. Type I, 850 ° F or Type IV, 1000° F Materials: Bonded with a thermosetting resin, UL/ULC Classified per UL 723 or FHC 25/50 per ASTM E 84, Environmental Product Declarations and/or Declare Red List Free if possible. Comply with ASTM C 547, Type I, and Type IV, ASTM 585, ASTM C 411 and ASTM C 795, with factory-applied ASJ+ - SSL+ or ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Cellular-Glass Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 ° F.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Products, Division of ITW; CP-96.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Products, Division of ITW; CP-82.
      c. ITW TACC, Division of Illinois Tool Works; S-90/80.
      d. Marathon Industries, Inc.; 225.
      e. Mon-Eco Industries, Inc.; 22-25.

2.4 MASTICS

A. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Knauf Insulation; EXPERT Mastics; KI-900 ASJ or KL-905 ASJ+.
      b. Childers Products, Division of ITW; CP-35.
      c. Foster Products Corporation, H. B. Fuller Company; 30-90.
      d. ITW TACC, Division of Illinois Tool Works; CB-50.
      e. Marathon Industries, Inc.; 590.
      g. Vimasco Corporation; 749.
   2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.04 perm (0.026 metric perm) at 40-mil (1.16-mm) dry film thickness.
   3. Service Temperature Range: Minus 20 to plus 180 ° F (Minus 29 to plus 82 ° C).

B. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Products, Division of ITW; CP-30.
      b. Foster Products Corporation, H. B. Fuller Company; 30-35.
      c. ITW TACC, Division of Illinois Tool Works; CB-25.
      e. Mon-Eco Industries, Inc.; 55-10.
   2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
   3. Service Temperature Range: 0 to 180 ° F.
2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Products, Division of ITW; CP-52.
   b. Foster Products Corporation, H. B. Fuller Company; 81-42.
   c. Marathon Industries, Inc.; 130.
   d. Mon-Eco Industries, Inc.; 11-30.
   e. Vimasco Corporation; 136.

2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.

3. Service Temperature Range: Minus 50 to plus 180 °F.


2.6 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Products, Division of ITW; CP-76.
   b. Foster Products Corporation, H. B. Fuller Company; 30-45.
   c. Marathon Industries, Inc.; 405.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Pittsburgh Corning Corporation; Pittseal 444.
   f. Vimasco Corporation; 750.

2.7 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136 and UL listed.

1. Products:
   a. Knauf Insulation; EXPERT Tapes; ASJ Tape or ASJ+ Tape.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
   c. Compac Corp.; 104 and 105.
   d. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
   e. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches

3. Thickness Total: 14.3 mil for ASJ


5. Elongation: 2 percent.

6. Tensile Strength: 40 lb/inch in width.

7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136 and UL listed.

1. Products:
   a. Knauf Insulation; EXPERT Tapes; FSK Tape.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
c. Compac Corp.; 110 and 111.
d. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
e. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches
3. Thickness: 13.3 mil.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

1. Products:
   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
   b. Compac Corp.; 130.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
   d. Venture Tape; 1506 CW NS.

2. Width: 4 inches
3. Thickness: 6 mils.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive and UL listed.

1. Products:
   a. Knauf Insulation; EXPERT Tapes; 2-mil foil tape.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   c. Compac Corp.; 120.
   d. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
   e. Venture Tape; 3520 CW.

2. Width: 3 inches
3. Thickness: 7.3 mils.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products:
   a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.

2. Width: 3 inches
3. Film Thickness: 4 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products:
   a. Dow Chemical Company (The); Saran 560 Vapor Retarder Tape.
2. Width: 4 inches.
3. Film Thickness: 6 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

2.8 FIELD-APPLIED JACKETS

A. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Pittsburgh Corning Corporation; Pittwrap.
   b. Polyguard; Insulrap No Torch 125.
   c. Venture Tapes; VentureClad.

2.9 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Products; Bands.
   b. PABCO Metals Corporation; Bands.
   c. RPR Products, Inc.; Bands.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal.

3. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch wide with wing seal.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Products: Subject to compliance with requirements, provide one of the following:
      1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
      2) GEMCO; Perforated Base.
      3) Midwest Fasteners, Inc.; Spindle.
   b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   c. Spindle: Stainless steel fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:
2.10 CORNER ANGLES
A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
   1. Verify that systems and equipment to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.
   3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION
A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS
A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. On all valves with handles reduce thickness to ½", install with 45° angle cut on larger insulation down to smaller insulation and apply masking. This is to prevent damage to the insulation with activation of the valve.

G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

H. Keep insulation materials dry during application and finishing.

I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

J. Install insulation with least number of joints practical.

K. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation tightly joining the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

L. Apply adhesives, mastics, and sealants at manufacturer’s recommended coverage rate and wet and dry film thicknesses.

M. Install insulation with non-self-adhesive factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches on center.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
      a. For below ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

N. Install insulation with self-sealing factory-applied jackets as follows:
   1. Locate all longitudinal pipe insulation jacketing laps in least visible location.
   2. Draw jacket tight and smooth.
   3. For proper sealing, seal lap joints with reasonable pressure being applied with a plastic squeegee or sealing tool.
   4. Vapor seal all circumference joints with a factory furnished matching pressure sensitive butt strips installed with reasonable pressure being applied with a plastic squeegee or sealing tool.
O. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

P. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

Q. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

R. For above ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.
   5. Handholes.
   6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant.

B. Insulation Installation at Below-Grade Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with vapor barrier coating.

C. Exterior Wall Penetrations: For penetrations of below grade exterior walls, extend metal jacket for exterior insulation through penetration to a point 2 inches from interior surfaces of wall inside the building. Seal ends of metal jacket with vapor barrier coating. Secure metal jacket ends with metal band. At point where insulation metal jacket contacts mechanical sleeve seal, insert cellular glass preformed pipe insulation to allow sleeve seal tightening against metal jacket. Tighten and seal sleeve to jacket to form a watertight seal.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   1. Comply with requirements in Division 07 Section "Penetration Firestopping" firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:
   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where specific requirements are specified in various pipe insulation material installation articles.
B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
   1. Install insulation over fittings, valves, strainers, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
   2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
   3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. But each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
   4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
   5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
   6. Do not insulate flanges and unions.
   7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

3.6 BELOW GROUND PIPE INSULATION INSTALLATION

A. General: The following are additional requirements for insulation applied to piping installed below ground.

B. Coat bare surfaces of insulation materials with insulating cement of type recommended by insulation manufacturer. Apply enough cement to fill surface cells. Do not use adhesives for this coating.

C. Secure insulation with a minimum of two stainless-steel bands for each section of insulation.

D. Secure insulation with a minimum of two reinforced tape bands for each section of insulation.

E. Terminate insulation at anchor blocks.

F. Apply insulation continuously through sleeves and manholes, except as specified above for exterior wall penetrations.
G. Finishing: Apply three coats of asphaltic mastic to a finish thickness of 3/16 inch over insulation materials. Apply 10 x 10 mesh glass cloth between coats. Overlap edges of glass cloth by 2 inches.

3.7 CELLULAR-Glass INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches O.C.
   4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
   4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
   2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of cellular-glass insulation to valve body.
   2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.

3.8 Glass Wool INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure pipe insulation to pipe using self-sealing lap system.
   2. On high-temperature piping, above 500 °F, apply insulation using double-layer and staggered joints. For double-layer installation, secure the unjacketed inner layer using filament tape; without deforming insulation material. All joints and ends must be firmly butted and secured with appropriate securing material.
   3. Firmly rub all longitudinal and circumferential joints using a squeegee or sealing tool.
4. Longitudinal jacket laps for pipe insulation installed on piping systems with operating temperatures below ambient shall be vapor sealed with factory-applied pressure-sensitive adhesive vapor retarder, self-sealing lap. For proper sealing, firmly rub lap joints with reasonable pressure being applied with a plastic squeegee or sealing tool. Vapor seal all circumferential joints with factory-furnished, matching pressure-sensitive butt strips installed with reasonable pressure being applied with a plastic squeegee or sealing tool. Additionally, coat raw edges of pipe insulation sections with vapor retarder mastic at 12 foot to 21 foot intervals; at Engineer’s discretion on straight piping, and on either side of all fittings, flanges or valves. Vapor retarder mastic shall completely coat the ends of the pipe and extend onto the bore of the pipe insulation and onto the jacketing a minimum of 2 inches.

5. Install metal shield between hangers or supports and the pipe insulation. Install rigid insulation inserts as required between the pipe and the insulation shields. Inserts shall be of equal thickness to the adjacent insulation and shall be vapor sealed as required. Insulation shield shall be no less than the following lengths:
   a. 1-1/2 inch to 2-1/2 inch IPS: 10 inch long.
   b. 3 inches to 6 inch IPS: 12 inch long.
   c. 8 inches to 10 inch IPS: 16 inch long.
   d. 12 inch and over IPS: 22 inches.

6. For piping subject to abuse in mechanical rooms or high traffic areas, protect insulation from mechanical abuse by the use of appropriate thickness of PVC jacketing, or laminated self-adhesive water and weather seal.

7. For piping exposed to the elements, install Redi-Klad pipe insulation with 4-inch butt strips and self-sealing lap, a jacket that shall be UV resistant PVC with a minimum thickness of 0.020 inch, a minimum 0.016-inch thick aluminum jacket with factory-applied moisture barrier, or a minimum 0.010-inch thick stainless steel jacket with factory-applied moisture barrier. Fittings shall be of similar materials or outdoor weatherable PVC. Apply all jacketing per manufacturer’s recommendations for the conditions.

8. For piping operating below ambient temperature or in high abuse areas, install Redi-Klad pipe insulation with 4-inch butt strips and self-sealing lap. Follow the same guidelines when using Redi-Klad as indicated for ASJ+-SSL+ above.

B. Insulation Installation for Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with glass mineral wool blanket insulation.
   4. Install jacket material with manufacturer’s recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed formaldehyde free glass mineral wool fittings; minimum 50 percent post-consumer recycled glass content, of same material as straight segments of pipe insulation when available.
   2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
D. Insulation Installation on Valves and Pipe Fittings:
   1. Install preformed formaldehyde free glass mineral wool fittings; minimum 50 percent post-consumer recycled glass content, of same material as straight segments of pipe insulation when available.
   2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to valve body.
   3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   4. Install insulation to flanges as specified for flange insulation application.

3.9 ROCK MINERAL WOOL INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
   4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with rock mineral wool or glass wool blanket insulation.
   4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of same material as straight segments of pipe insulation when available.
   2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   4. Install insulation to flanges as specified for flange insulation application.

3.10 FINISHES

A. Equipment and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.
1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
   

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer’s recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

3.11 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor’s option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
   
1. Underground piping.
2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.12 INDOOR PIPING INSULATION SCHEDULE

<table>
<thead>
<tr>
<th>PIPE INSULATION SCHEDULE</th>
<th>SECTION 220700</th>
</tr>
</thead>
<tbody>
<tr>
<td>SERVICE</td>
<td>PIPE SIZE</td>
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<tr>
<td>Domestic Water Heater</td>
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<tr>
<td>Domestic Hot Water</td>
<td>Over 2&quot;</td>
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<tr>
<td>Domestic Hot Water Return</td>
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<td>Roof Drain Bodies</td>
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<td>Horizontal Rain Conductors</td>
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<tr>
<td>Domestic Cold Water Drops to Fixtures (In Walls Only)</td>
<td>Up to 1-1/2&quot;</td>
</tr>
</tbody>
</table>

PLUMBING INSULATION

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PIECE INSULATION SCHEDULE

<table>
<thead>
<tr>
<th>Fixtures (In Walls Only)</th>
</tr>
</thead>
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NOTES

1. 2" thick on all heat-traced piping where shown on Drawings.
2. Within 10'-0" of the vent through roof.
3. In areas designated as "Interstitial" any insulated piping that is installed in such a matter that it could be climbed over shall have protective PVC jacketing. See the plans for areas indicated to be PVC Jacketed.
4. Plenum wrap is to be installed on all PVC piping in the interstitial space.
5. Any sanitary, storm, or clear water waste piping with in 24" of the finished ceiling shall be insulated.
6. Any sanitary, storm or clear water piping 8" and over shall have vertical portions of piping including elbow are to be insulated 5'-0" in the vertical either up or down.

(Notes above are based on previous projects, edit or modify per project).

3.13 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Domestic Cold and Domestic Hot Water, All Sizes: Cellular glass, 2 inches thick.

END OF SECTION 220700
SECTION 220800 – COMMISSIONING of PLUMBING

PART 1 - GENERAL

1.1 SCOPE

A. The purpose of this section is to specify the Division 22 responsibilities and participation in the commissioning process.

B. Work under this contract shall conform to requirements of Division 01, General Requirements, Conditions of the Contract and Supplementary Conditions. This specification covers commissioning of plumbing systems which are part of this project.

C. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.

1.2 REFERENCE

A. Applicable provisions of Division 1 govern work under this section.

B. Specific performance requirements are given in the following sections of these specifications:

1. Division 01 Section "Project Management and Coordination"
2. Division 01 Section "Submittal Procedures"
3. Division 01 Section “Sustainability Certification Project Requirements”
4. Division 01 Section "Waterborne Contaminants Control"
5. Division 01 Section "Starting and Adjusting"
6. Division 01 Section “Testing and Inspection Services”
7. Division 01 Section "Closeout Procedures"
8. Division 01 Section "Closeout Submittals"
9. Division 01 Section "Demonstration and Training"
10. Division 01 Section “General Commissioning Requirements”
11. Division 20 Section “Functional Performance Testing Common Work Results, Division 21 – 28”
12. Division 22 Section “Instrumentation and Control of Plumbing”
13. Division 22 Section “Water Management for Construction”
14. Division 25 Section “Commissioning of Integrated Automation”

C. Water Quality and Safety: additional coordination is required with Division 22 Section "Water Management for Construction" to assure the building water distribution system and all plumbing components for functional performance are in alignment with the Owner’s water management program for healthcare operations. All performance criteria for plumbing must not impede the Owner’s ability to process water through the building water distribution system or diminish water quality and safety standards per the US EPA Safe Drinking Water Act or ANSI/ASHRAE Standard 188 Legionellosis: Risk Management for Building Water Systems.

D. Sustainable Design Intent: Comply with project requirements to meet the applicable commissioning prerequisites and credits pursued for the Sustainability/Sustainable Green Building Rating System, of the US Green Building Council.
1.3 DEFINITIONS

A. Commissioning (Cx): The process of ensuring that systems are designed, installed, functionally tested and performing in conformity with Owners Project Requirements (OPR) the design intent (Basis of Design BoD)) and that the building operator has received complete equipment and systems documentation and training.

B. Commissioning Provider (CxP): The entity identified to lead, monitor, coordinate and report on project commissioning activities.

C. Commissioning Plan: A detailed plan of the organization, schedule, allocation of resources, procedures and documentation requirements of the commissioning process.

D. Construction Verification (CV): A quality control verification process performed by the installer as building assemblies, components, equipment and systems are being installed which documents that the materials, installation procedures, interfaces with other trades, start-up, testing and operation are correct, complete and in compliance with contract documents and manufacturer’s recommendations and are ready for functional performance testing.

E. Functional Performance Tests (FPT): Contractor testing of installed building assemblies, components, equipment, systems and interfaces which confirms correct performance through all operating modes and compliance with contract documents and manufacturer’s recommendations.

F. Water Quality and Safety Performance Tests: Contractor shall review testing criteria as stated in Division 22 Section “Water Management for Construction.”

G. Commissioning Report: A document that records the activities and results of the commissioning process.

1.4 COORDINATION

A. Commissioning Team: The members of the commissioning team consist of the Commissioning Provider (CxP), the Owner's Project Manager (OPM), the Construction Manager or General Contractor (CM or GC), the design Architect and Engineers (A/E), the Mechanical Contractor (MC), the Electrical Contractor (EC), the Testing, Adjusting, and Balancing contractor (TAB), the Controls Contractor (CC), the Communications and Technology Contractor (CTC), the Owner’s maintenance staff, and any other installing subcontractors or suppliers of equipment.

1. Review Division 22 Section “Water Management for Construction” for related team members.

B. Management: The general contractor that is awarded the project shall not include the cost of the Commissioning Provider in their price. The general contractor (and their sub-contractors) shall include cost for their involvement in the commissioning process as described in this section and other related commissioning sections, including completion of construction verification checklists, demonstration of installed equipment to the commissioning team members during the functional performance testing portion of the project.

C. Scheduling: The CM/GC shall integrate all commissioning activities into the master construction schedule. A timeline determined by the commissioning agent will be dedicated for system commissioning. The MEP Contractors shall coordinate their commissioning schedule needs with CM prior to the start of construction to ensure inclusion into the overall construction schedule. The CxP will work with the OPM and CM/GC to schedule commissioning activities. All parties will address scheduling issues in a timely manner in order to expedite the commissioning process.
1. Review Division 22 Section “Water Management for Construction” for related project schedule for water activation milestones to assure water quality and safety of the building water distribution system.

D. Tracking Contractor Required Testing: Each contractor is responsible for completing various tests per their associated specifications. Each contractor will forward a list of their associated tests to the CxP, who will generate an overall list for tracking purposes.

1.5 COMMISSIONING PROCESS

A. The following activities describe the commissioning tasks and the general order in which they occur. The CxP coordinates all activities.

1. Scoping Meeting: All members of the design and construction team that will be involved in the commissioning process meet and agree on the scope of work, tasks, schedules, deliverables, and responsibilities for implementation of the Commissioning Plan.

2. Commissioning Plan: The Commissioning Plan developed by the CxP provides guidance in the execution of the commissioning process. The Specifications take precedence over the Commissioning Plan.

3. Submittals: Contractor submittals, including detailed start-up procedures, applicable to systems being commissioned is submitted to the CxP to be reviewed concurrent with the A/E’s review. The CxP will review contractor submittals for compliance with OPR and BoD.

4. Site Visits: Commissioning is a team effort requiring the cooperation of all parties. Contractors are to proactively carry out their commissioning responsibilities and are to assist the CxP during site visits in performing commissioning tasks. This includes providing access to and demonstrating the installation, operation and testing of commissioned systems; responding to CxP requests for information; carrying out proactive and corrective actions; and accurate reporting on system status and conditions.

5. Start-Up/Construction Verification Checklists: The CxP works with the Subcontractors to develop startup plans and documentation formats, including providing the Subcontractors with construction verification checklists to be completed prior to the acceptance testing process.

6. Functional Performance Testing: The CxP develops specific equipment and system functional performance test procedures. The Subcontractors review the procedures. The procedures are executed by the Subcontractors, under the direction of, and documented by the CxP.

7. Water Quality and Safety Performance Testing: The CxP coordinates the specific equipment and system functional performance test procedures in conjunction with Division 22 Section “Water Management for Construction” for water quality and safety testing of the building water distribution system.

8. Deficiencies and Resolution: The CxP documents items of non-compliance in materials, installation or operation in an Issues Log. The items are corrected at the Sub’s expense and the equipment or systems are retested. Each contractor is responsible for completing action items in a timely manner that are noted in the Issues Log as their responsibility. Timely response and successful completion are a requirement to avoid withholding of payment. The CM/GC will be responsible for any cost associated with the CxP for retesting.

9. Operations and Maintenance Documentation: The CxP reviews the Operation and Maintenance documentation provided by the Subcontractors for completeness.

10. Training: The CxP reviews the training provided by the Subcontractors and verifies that it is completed.

11. Seasonal Testing: Deferred or seasonal testing is conducted, as required.
12. Warranty Review: The CxP will review status of warranty and building performance issues with the OPM, A/E, CM/GC roughly 10 months after occupancy.

1.6 RESPONSIBILITIES

A. The responsibilities of various parties in the commissioning process are provided in this section. Note that the services for the Owner’s Project Manager, Design Team, and Commissioning Provider are not included in this contract. The Contractor is not responsible for providing their services. Their responsibilities are listed here to clarify the commissioning process.

B. Commissioning Provider (CxP): The CxP is not responsible for design concept, design criteria, code compliance, general construction scheduling, cost estimating, or construction management. The CxP may assist with problem-solving deficiencies, but ultimately that responsibility resides with the General Contractor and the A/E. The primary role of the CxP is to develop and coordinate the execution of a testing plan to verify and document that systems are functioning in accordance with the design intent and the Construction Documents.

1. Construction and Acceptance Phase:
   a. Coordinates and directs all commissioning activities. Work with the CM/GC and OPM to confirm that commissioning activities are scheduled.
   b. Maintain an up-to-date Commissioning Plan.
   c. Coordinate all activities with Division 22: “Water Management for Construction”
   d. Plan and conduct the commissioning scoping meeting.
   e. Request and review additional information required to perform commissioning tasks, including Operation and Maintenance materials, contractor start-up and checkout procedures, and sequences of operation.
   f. Review Contractor submittals applicable to commissioned systems.
   g. Assist Subcontractors with the development of start-up and checkout plans.
   h. Write and distribute construction verification checklists to be completed by the responsible Subcontractor.
   i. Perform site visits, as necessary, to observe component and system installations. Attend construction job-site meetings, water management for construction team meetings, as necessary, to monitor construction and commissioning progress.
   j. Review completed construction verification checklist and start-up reports.
   k. Assist with coordination of start-up requirements with TAB requirements.
   l. Write functional performance test procedures for equipment and systems.
   m. Coordinate, witness, and document functional performance tests completed by installing contractors. Coordinate retesting as necessary until satisfactory performance is verified.
   n. Maintain a master deficiency and resolution record. Provide the OPM with written progress reports and test results with recommended actions.
   o. Review the training proposed by the contractors for the Owner’s operating personnel.
   p. Review the Operation and Maintenance manuals.
   q. Prepare a final commissioning report.

2. Warranty Period:
   a. Coordinate and supervise required seasonal or deferred testing and deficiency corrections.
   b. Assist in the development of a preventative maintenance plan and review as-built documentation.
C. Design Team (A/E):

1. Construction and Acceptance Phase:
   a. Attend commissioning scoping meeting and additional meetings, as necessary.
   b. Provide design intent and sequence of operation documentation as required by the CxP.
   c. Assist in resolution of system deficiencies identified during commissioning.
   d. Review and approve the operations and maintenance manuals.

2. Warranty Period:
   a. Assist in resolution of system deficiencies identified during warranty period commissioning.
   b. Attend the end-of-warranty review walkthrough to assist in identifying issues requiring resolution and the action plan to do so.

D. Owner’s Project Manager (OPM):

1. Construction and Acceptance Phase:
   a. Manage the contract of the CxP.
   b. Attend commissioning scoping meeting and additional meetings, as necessary.
   c. Arrange for facility operating and maintenance personnel to participate in commissioning activities and training sessions.
   d. Provide final approval for the completion of the commissioning work.

2. Warranty Period:
   a. Ensure that any seasonal or deferred testing and any deficiency issues are addressed.
   b. Attend the end-of-warranty review.

E. General Contractor or Construction Manager (CM or GC):

1. Construction and Acceptance Phase:
   a. Facilitate the coordination of the commissioning work by the CxP.
   b. Attend commissioning scoping meeting and additional meetings, as necessary.
   c. Furnish copies of construction documents, addenda, change orders and approved submittals and shop drawings related to commissioned equipment to the CxP.
   d. Confirm that Subcontractors execute their quality assurance and commissioning responsibilities according to the Specifications and Commissioning Plan.
   e. Ensure CxP access to observe and witness equipment system installation and operation.
   f. Coordinate the training of Owner personnel, according to the Specifications.
   g. Prepare Operation and Maintenance manuals, according to the Specifications, including updating original sequences of operation to as-built conditions.
   h. Attend regularly scheduled commissioning meetings and water management for construction team meetings.

2. Warranty Period:
   a. Confirm that Subcontractors execute required seasonal or deferred functional performance testing.
   b. Confirm that Subcontractors correct deficiencies and make necessary adjustments to Operation and Maintenance manuals and as-built drawings for issues identified during the warranty period.
   c. Attend the end-of-warranty review.
F. Equipment Suppliers:

1. Provide requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in effect.
2. Provide information requested by CxP regarding equipment sequence of operation and testing procedures.
3. Assist in equipment testing and training per agreements with Subcontractors.

G. Mechanical, Electrical, Plumbing, Controls, TAB and other Sub-Contractors:

1. Installing subcontractors shall fill out construction verification checklists generated by the CxP.
2. The sub-contractor responsible for the startup and operational checkout of each commissioned system shall participate in functional performance testing and execute the test plans generated by the CxP.
3. Attend regularly scheduled commissioning meetings.
4. Ensure CxP access to observe and witness equipment system installation and operation
5. Submit required Contractor quality assurance test reports to Architect and Commissioning Provider for review.
6. Submit completed start-up reports for commissioned equipment signed by the factory-trained and authorized representatives performing the associated work.
7. Submit Testing and Balancing plan for review and completed TAB report to Architect and Commissioning Provider for review.
8. Submit completed System Readiness Checklists, with completed startup sheets attached, to Commissioning Provider. System functional performance testing shall not commence until the system is documented as ready for testing.
9. Submit operation and maintenance (O&M) manuals for systems being commissioned to Architect and Commissioning Provider for review.
10. Provide training for the Owner’s facility staff for regular operations, maintenance, and troubleshooting.
11. Refer to applicable quality assurance and commissioning sections as noted in Section 1.2 for additional responsibilities.

1.7 COMMISSIONING SCOPE

A. The following checked equipment shall be commissioned for this project.
B. Existing downstream devices and terminal units of new primary equipment shall be included in the commissioning scope.
C. FPT sample is 100% unless noted otherwise.
D. Integrated systems interactions between HVAC, Electrical, etc. shall be tested. Reference Division 20 Section “Functional Performance Testing Common Work Results, Division 21 – 28”

<table>
<thead>
<tr>
<th>System</th>
<th>Equipment</th>
<th>FPT Sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division 22</td>
<td>Plumbing Systems</td>
<td></td>
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<tr>
<td></td>
<td>Domestic Hot Water Heating</td>
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<td></td>
<td>Booster and Circulation Pumps</td>
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<td></td>
<td>Hot Water Mixing Station</td>
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<td></td>
<td>Backflow Preventers (No FPT)</td>
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<td></td>
<td>Sump/Ejector pumps</td>
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<tr>
<td></td>
<td>Water Treatment</td>
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<tr>
<td></td>
<td>Fixtures</td>
<td>50%</td>
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</tbody>
</table>
### PART 2 - PRODUCTS

#### 2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested. Equipment to be calibrated within the past year and in accordance with the manufacturer’s recommendations.

B. Contractors to provide the electronic means (equipment) required to enter construction verification data from on site if the Commissioning Provider utilizes a web-based program.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed.

D. All testing equipment shall be of sufficient quality and accuracy to test or measure system performance as required by the specifications.

E. Datalogging equipment or software required to test equipment provided by the CxP shall not become the property of the CM/GC or Owner.

### PART 3 - EXECUTION

#### 3.1 MEETINGS

A. Pre-Construction Scoping Meeting: The CxP will schedule, plan and conduct a pre-construction scoping meeting with the entire commissioning team in attendance. The CM/GC will ensure all relevant Subcontractors attend. The CxP will present an overview of the project’s commissioning process and the commissioning team members will be identified and their responsibilities reviewed.

B. Miscellaneous Meetings: Other meetings will be planned and conducted by the CxP as construction progresses. Each contractor is required to attend all meetings related to commissioning (pre-construction, construction progress, commissioning meetings, etc.) and to have personnel requested by CxP in attendance to facilitate quality control and coordinate commissioning efforts. Contractors are to provide a review of project progress, a report on the status of issues, commissioning tasks and scheduling for future commissioning tasks.

C. Warranty Review Meeting: Within 10 months of substantial completion and prior to completion of the warranty period, CxP will coordinate and facilitate a review meeting. The intent of the meeting will be to review the project design, construction, turnover, operation and warranty issues. Contractor is required to have key project personnel in attendance and participating in the review for the purposes of making future project delivery improvements.

D. The CxP will distribute meeting minutes to all parties.
3.2 REPORTING
   A. The CM/GC shall include the CxP on all OAC construction meeting minutes distribution.
   B. The CM/GC shall include the CxP on all Requests For Information (RFI) and Change Order Requests (COR) related to commissioned equipment and systems.
   C. The CxP will regularly communicate with all members of the commissioning team, apprising them of commissioning progress and scheduling changes through memos, progress reports, etc.
   D. The CM/GC will respond to the CxP’s deficiency record with resolution updates.
   E. The CM/GC will provide documentation as required for the CxP to compile a final Commissioning Report which summarizes all of the tasks, findings, and documentation of the commissioning process. The report addresses the actual performance of the building systems in reference to the design intent and contract documents. The report includes a summary of commissioning activities, contact and warranty information, completed construction verification checklists, functional performance testing records, coordination with Owner’s safety performance testing, diagnostic monitoring results, identified deficiencies, recommendations for warranty review meeting and ongoing commissioning effort.

3.3 SUBMITTALS
   A. Refer to Division 01 General Requirements and Section “Submittals” and relevant Division sections for requirements.
   B. The CM/GC shall provide the CxP submittals related to the commissioned equipment to review for conformance to the Construction Documents as it relates to the commissioning process. The review is intended primarily to aid in the development of functional performance test procedures and Owner’s safety performance testing.
   C. The CM/GC shall respond to request for additional information from the CxP as needed to facilitate the commissioning process.
   D. The CxP may request additional design and operations narrative from the design team and Controls Contractor regarding sequences of operations.

3.4 START-UP and CONSTRUCTION VERIFICATION CHECKLISTS
   The following procedures apply to all equipment to be commissioned, according to Section 1.7, Commissioning Scope.
   A. Start-Up Plans:
      1. The responsible contractors shall develop detailed start-up plans for all equipment to be commissioned. The CxP will review start-up plans to confirm that there is written documentation that each of the manufacturer-recommended procedures is completed.
      2. All start-up plans shall be coordinated and consistent with the Owner’s Water Management for Construction program and schedule of activities.
      3. Subcontractors and equipment suppliers schedule startup and checkout with the OPM, CM/GC and CxP.
      4. All work to be installed in accordance with the manufacturer’s instructions. The subcontractors and vendors execute manufacturer installation procedures and start-up documentation. A copy of completed start-up checklists shall be provided to the CxP.
      5. The start-up plans and documentation may be provided to the OPM and A/E for review.
B. Construction Verification Checklists:

1. The construction verification checklists are a formalized means to provide individual workers the criteria for a successful installation, adherence to the construction documents and to easily track construction progress.

2. Each assembly, component, equipment, system and interface to be commissioned shall be verified by the installer at the site while work is underway and documented on the construction verification checklists. The contractor is responsible for successfully completing installations, documenting this on the construction verification checklist forms and correcting all deficiencies.

3. Construction verification checklists are developed by the CxP for all major equipment and systems being commissioned. The checklist documents all equipment components are installed and functional and confirms the as-built status of the equipment or system. These checklists also assist in confirming that the systems are complete and operational, so that the functional performance testing can be scheduled.

4. Construction verification checklists will be electronic and available via a web-based program. It is the contractor’s responsibility to have an electronic means of entering this data on site.

5. Construction verification checklists shall be filled out and signed by the installing subcontractor for each piece of equipment. Only individuals who have completed or witnessed the line item task shall complete and sign the checklists.

6. Contractor shall periodically review the construction verification checklist schedule with the CxP allowing advance notice of activities of 5 business days so that the CxP may witness as deemed necessary.

7. Calibration of all sensors shall be included as part of the construction verification checklists performed by the Contractors.

C. Deficiencies, Non-Conformance, and Approval in Checklists and Startup:

1. The Subcontractors shall clearly list any items of the start-up and construction verification procedures not successfully completed at the bottom of the form or on an attached sheet. The procedures form and any outstanding deficiencies are provided to the CxP within two days of test completion.

2. The CxP will verify the accuracy of the completed start-up forms and construction checklists compared with actual field installation and recommends approval to the OPM.

3. If CxP identifies more than a 10% discrepancy rate during confirmation of construction verification checklists, the contractor shall correct all deficiencies and revalidate all items covered by that checklist and resubmit new checklists.

4. The cost of reconfirmation of construction verification checklists due to equipment or construction deficiencies is the responsibility of the contractor and subject to deductive change order at owner’s/construction manager’s discretion. Correction of deficiencies and revalidation are the responsibility of the contractor and are not subject to time extensions or delay claims.

3.5 FUNCTIONAL PERFORMANCE TESTING

A. Functional performance testing for each system in the commissioning scope shall be executed by the sub-contractor responsible for the startup and operational checkout of the system.

B. All functional performance testing shall be coordinated and consistent with the Owner’s Water Management for Construction program and schedule of activities.

C. The following procedures apply to all equipment to be commissioned, according to Section 1.7, Commissioning Scope. This sub-section applies to all commissioning functional performance testing for all divisions.
D. Objectives and Scope: The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Construction Documents. Functional performance testing comprises a full range of tests to verify that all components, equipment, systems, and interfaces between systems operate correctly. This includes all operating modes, interlocks, control sequences, and responses to emergency conditions. All verification procedures are directed, witnessed, and documented by the CxP.

E. Development of Test Procedures: The CxP develops specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Prior to execution, the CxP provides the test procedures to the Sub(s) who review the tests for feasibility, safety, equipment and warranty protection. The CxP may submit the tests to the A/E team for review.

F. Test Methods:
1. Functional performance testing and verification may be achieved by direct manipulation of system inputs (i.e. heating or cooling sensors), manipulation of system inputs with the building automation system (i.e. software override of sensor inputs), trend logs of system inputs and outputs using the building automation system, or short-term monitoring of system inputs and outputs using stand alone data loggers. A combination of methods may be required to completely test the complete sequence of operations. The CxP determines which method, or combination, is most appropriate.

2. Setup: Each test procedure is performed under conditions that simulate normal operating conditions as closely as possible. The Sub executing the test provides all necessary system modifications to produce the specified conditions (flows, pressures, temperatures, etc) necessary to execute the test. At completion of the test, the Sub returns all affected building equipment and systems to their pre-test conditions.

3. Sampling: Multiple identical pieces of non-life-safety or non-critical equipment may be functionally tested using a sampling strategy. The CxP shall establish sampling protocol with approval of the OPM, and at the time of testing select sample test locations for identical pieces of equipment. Where simulation of conditions or altering of setpoints or values is required to achieve an operating or failure mode for testing, the contractor must receive CxP approval. If, after three attempts at testing the specified sample percentage, failures are still present, then all remaining units are tested at the contractors’ expense.

G. Coordination and Scheduling: Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures.

H. Contractor shall coordinate functional performance testing with CxP, the construction manager, and the owner and notify them 5 business days prior to testing so that they may witness and document the test results. All contractors involved with specific assemblies, components, equipment, systems and interfaces shall have qualified installers and technicians present at the same time working together to perform testing and demonstrate correct performance through all operating and failure modes and compliance with contract documents and manufacturer’s recommendations.

I. With Owner and CM oversight, the CxP is responsible for witnessing functional performance testing and recording the results and deficiencies. The following sequential priorities are followed:
1. Equipment is not “temporarily” started (for heating or cooling), until pre-start checklist items and all manufacturers’ pre-start procedures are completed and moisture, dust and other environmental and building integrity issues have been addressed.
2. Functional performance testing does not begin until construction verification, start-up, controls verification of installation (all sequences and points), and TAB is completed for a given system.

3. The controls system and equipment it controls are not functionally tested until all points have been calibrated and construction verification checklists are completed.

J. Contractors are responsible for completing and coordinating their work with all trades prior to testing, preplanning testing procedures, ensuring necessary staff and resources are on hand and expediting testing. This includes, but not limited to, completing testing and balancing by the HVAC contractor required for successful functional performance testing, pre-testing of the systems (completing FPT) prior to testing with CxP. Pre-testing will include submission of trending per the request of CxP. Failure to complete or coordinate work, preplan or have staff and resources available to carry out testing will result in retesting.

K. Problem Solving: The CxP may recommend solutions to deficiencies identified during functional testing. However, the burden of responsibility to solve, correct and retest deficiencies is with the CM/GC, Subcontractors and A/E.

3.6 FLUSHING AT INITIAL WATER ACTIVATION

A. All flushing activities shall be coordinated and consistent with the Owner’s Water Management for Construction program and schedule of activities.

B. Additional flushing activities to avoid stagnant water conditions are required to be performed by the Contractor and described within the Owner’s Water Management for Construction program.

C. The interior of all pipes shall be free from loose mill scale, sand, dirt, slag, weld splatter, rust and other foreign matter when erected. Coordinate with water treatment contractor.

D. After erection and welding of piping, all those lines requiring hydrostatic testing shall be flushed with clean water by Contractor. Terminal visual inspection shall occur in the presence and to the satisfaction of the Owner.

E. After erection of piping, all those lines requiring hydrostatic testing shall be blown free of dirt and debris with clean, dry air by the Contractor. Terminal visual inspection shall occur in the presence and to the satisfaction of the Owner.

F. Upon completion of flushing, all lines shall be drained at all low points.

G. Clean potable cold water shall be used for all water flushing. Maintain a reasonable velocity to ensure complete removal of all scale, bacteria, weld splatter and other debris. Drain water to sewer.

H. Prior to operating any permanently installed in-line pumping equipment, precautions shall be taken to ensure that the pump suction piping is sufficiently cleaned to prevent damage to operating system equipment.

I. Pump operation must be observed and controlled to prevent pump "run out" or "dead heading" during the flushing.

J. After flushing every precaution shall be taken to protect the system from recontamination. Primary attention should be made toward keeping "clean" piping sealed off.

K. Pump suction strainer differential pressure gauges will be monitored and pump operation observed to prevent pump cavitations. Where strainer differential pressure gauges are not available, the strainers will be pulled and checked periodically for particulate build-up.
L. All exceptions and deficiencies that occurred during the flushing operations shall be noted, and corrected as required and coordinated with the Owner’s water management for construction program and schedule of activities.

3.7 CLEANING

A. All cleaning and disinfection activities shall be coordinated and consistent with the Owner’s Water Management for Construction program and schedule of activities.

B. Water systems impacted by work shall be cleaned as described in this section for all projects involving over 20 domestic water fixtures and/or 10,000 SF.

C. Clean piping systems thoroughly. Purge pipe of construction debris and contamination before placing the systems in service. Use whatever temporary connections are required for cleaning, purging and circulating. Cleaning work shall not be performed until the systems are thoroughly flushed, hydrostatically or pneumatically tested and reviewed by the Owner.

D. Install temporary strainers on suction side of pumps and inlets to tanks, solenoid valves, control valves, and other equipment where permanent strainers are not indicated. Keep these strainers in service until the equipment has been tested, then remove either entire strainer or straining element only. Fit strainers with a line size blow off valve.

E. Prior to disinfection, all system elements that could be damaged by disinfectant (filters, ion exchangers, etc.) shall be isolated from remainder of system.

F. Water piping shall be disinfected in accordance with the Plumbing Code. The complete system shall then be rinsed with clean, potable water and drained. For new construction, final water quality shall, at a minimum, match that of the incoming municipal water. For renovations, initial water quality shall be measured prior to beginning work. Final water quality shall, at a minimum, match initial.

G. Acceptance: Prepare a report based on the satisfactory completion of the cleaning of each piping system or portion of the system and submit to Engineer of Record and Owner’s Water Committee. The report shall establish the exact limits of the cleaning. When signed and dated by the Owner, the report shall constitute substantial completion except as noted therein. This report shall contain the cleaning method used, duration of cleaning, disinfecting levels, and other information requested by the Owner. This report shall also include a Contractor supplied marked-up set of Piping Drawings, with the sections of pipe which were cleaned to be yellowed-pit and initialed by the Contractor and Owner as they are cleaned. The Contractor shall be responsible for maintaining this set of drawings, which shall be given to the Owner at the completion of the job.

3.8 SUMP PUMP

A. Parties Responsible to Execute Functional Test:

1. Electrical Contractor
2. Plumbing Contractor: Operate the controls to activate the equipment.
3. CxP: To witness and document testing.
4. Manufacturer’s Representative.

B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.

1. Float switch settings
2. Minimum run timer
3. High water alarm
C. Prerequisites:
   1. The applicable prerequisite checklist items listed in Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Pumps:
   1. Check suction line connections for tightness to avoid inducing air into the pump.
   2. Check motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.
   3. Check that pump is free to rotate by hand.
   4. Clean associated strainers.
   5. Verify that OSHA approved coupling guards are in place.
   6. Check that the proper overloads have been installed in the starter and that overloads are the correct size.
   7. Verify that the integrity of the vibration isolation is maintained throughout the support and the piping connections.
   8. Align pump within manufacturer’s recommended tolerances.
   9. Ensure that all associated piping has been cleaned, tested and deaerated.
  10. Start the pump and check that all seal piping/installation is per manufacturer’s instructions.
  11. Verify that all thermometers and gauges are installed, are clean and undamaged, and are functional.
  12. Verify that the check valve seal is appropriate for the application.
  13. Check noise and vibration levels and ensure that they are within the manufacturer’s recommended tolerances.
  14. Check that the NPSH is within the allowable parameters for the operating condition.

E. Functions/Modes Required To Be Tested, Test Methods:
   1. The following testing strict accordance with the requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

<table>
<thead>
<tr>
<th>Function/Mode</th>
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</thead>
<tbody>
<tr>
<td>General</td>
</tr>
<tr>
<td>1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, shutdown and power failure. Test functionality of this piece of equipment or system in all control strategies or interlocks that it is associated with.</td>
</tr>
<tr>
<td>2. Verify set points and run times to be reasonable and appropriate.</td>
</tr>
<tr>
<td>3. Verify operation and activation of high water alarm at all locations.</td>
</tr>
</tbody>
</table>

F. Special Procedures (other equipment to test with, etc.; reference to function ID): None

G. Sampling Strategy: Test all units.

END OF SUMP PUMP
3.9 PLUMBING WATER SYSTEM

A. Parties Responsible to Execute Functional Test
1. CA: witness and document testing.
2. Plumbing Contractor to make all adjustments.

B. Integral Components or Related Equipment Being Tested
1. This procedure applies to the following systems:
   a. Hot and Cold Domestic Water Systems
      1) Fixtures (sinks and showers) for temperature
         a) Hot water distribution (fixture temp and point-of-use mixing valves)
         b) Cold water distribution (fixture temp)
   b. Hot and Cold Non-Potable Water Systems
2. Hot water heaters (heaters, mixing valves)
3. Recirculating pumps

C. Prerequisites: The applicable prerequisite checklist items shall be checked off prior to functional testing. The commissioning agent may also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Valves:
1. Operate all manual and automatic valves through their full stoke. Ensure smooth operation through full stroke and appropriate sealing or shutoff.
2. Verify that actuators are properly installed with adequate clearance. For automatic, pneumatically-operated valves, verify spring range and adjust pilot positioners where applicable.

E. Meters and Gauges:
1. Adjust faces of meters and gauges to proper angle for best visibility.
2. Clean windows of meters and gauges, including factory-finished surfaces. Replace cracked and broken windows and repair scratched and marred surfaces with manufacturer's touch-up paint. For meters and gauges that require temporary manual connection of read-out device such as pressure taps on a flow measuring device, ensure that threads are clean and that connection can be easily made.
3. Meters and gauges requiring manual connection of readout device shall be installed with adequate access to allow connection of device with normal tools.

F. Identification:
1. Verify that all valve tags, piping, and equipment labeling corresponds with the Drawings and indexes and meets requirements specified. Correct any deficiencies for all piping and duct systems.
2. Adjusting: Relocate any identification device which has become visually blocked by Work of this Division or other Divisions.
3. Cleaning: Clean the face of identification devices and glass frames of valve charts.
G. Plumbing Insulation:
1. Examine all systems and equipment specified to be insulated.
2. Patch and repair all insulation that has been damaged after installation.
   a. Ensure the integrity of the vapor barrier around all cold surfaces.

H. Piping:
1. The following applies to all installed piping systems including underground Site utilities. Responsibility for preparation of the Prefunctional Checklist and testing of the piping systems generally lies with the installing Subcontractor.
   a. Inspect all piping for proper installation, adequate support with appropriate vibration isolation where applicable, and adequate isolation valves for required service.
   b. Flush and treat all piping as appropriate to the application and clean all strainers.
   c. Pressure and/or leak test all applicable systems in accordance with requirements in the applicable Specification Sections. Record pressure testing results and certification that piping meets the Specification.
   d. Sterilize applicable piping systems as specified in the individual Specification Sections and as required by regulatory authorities. Record the results of sterilization and all parameters during this process and certify that the piping meets the Specification.
   e. Submit test reports that document testing results and certification of results.
   f. Verify the operation of applicable safety relief valves, operating controls, safety controls, etc. to ensure a safe installation. Document setting and actual trip points of all such controls.
   g. Set and adjust fill, pressure, or level controls to the required setting.
   h. Compare installation with mark-up as-built Drawings to ensure the drawing accuracy.

I. Storage Tanks:
1. Inspect the tank for proper installation and support in conformance with the manufacturer’s recommendations.
2. Verify that all required instrumentation is provided and installed in accordance with the Contract Documents.
3. For pressurized tanks, pressure test the tanks per the requirements in the applicable Specification Section and per the ASME Code where applicable.
4. Non-pressure Testing: Fill non-pressure water storage tanks to water operating level to ensure structural integrity and freedom from leaks. Hold water level for two (2) hours with no drop in water level.
5. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.
6. Clean and disinfect water storage tanks for use with potable water systems as specified in the respective Section.
7. Prepare and submit reports for all testing, purging, and disinfecting activities.
8. Check that pressure relief valves have correct setting.
9. Test operation of tank accessories and devices.
10. Adjust vacuum relief valves.
11. Manually operate relief valves.
12. Adjust pressure and vacuum settings.
J. Water Heaters:
   1. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide Start-up service, and demonstrate and train Owner's personnel as specified below.
      a. Check for adequate steam supply and piping per manufacturer's direction.
      b. Check for leaks at piping connections.
      c. Check that recirculation and control requirements are per manufacturer's recommendations.
      d. Check for temperatures for supply and hot water return are in accordance with the Owner’s Water Management Program.
      e. Check adequate condensate removal and venting of steam.
      f. Verify that steam traps are working properly.
      g. Verify that modulated steam is not being lifted.
      h. Set and test relief valves and record test parameters.
      i. Test and adjust operating and safety controls. Replace damaged and malfunctioning controls and equipment.
      j. Record all Start-up procedures and parameters in Prefunctional Checklists.
      k. For condensing water heaters, verify that condensate neutralization measures are in place.

K. Functions/Modes Required To Be Tested, Test Methods and Seasonal Test Requirements

<table>
<thead>
<tr>
<th>Function/Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, shutdown, unoccupied &amp; manual modes and power failure. Test functionality of this piece of equipment or system in all control strategies or interlocks that it is associated with.</td>
</tr>
<tr>
<td>2. Verify schedules and set points to be reasonable and appropriate</td>
</tr>
<tr>
<td>3. Mixing valve operation and temperature control</td>
</tr>
<tr>
<td>4. Sensor calibration checks on hot water temperature</td>
</tr>
</tbody>
</table>

L. Special Procedures (other equipment to test with, etc.; reference to function ID)
   1. None

M. Required Monitoring
   1. None

N. Acceptance Criteria (Referenced by function or mode ID)
   1. For the conditions, sequences and modes tested, equipment responds to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

O. Sampling Strategy for Identical Units
   1. No sampling. Test all units.

END OF PLUMBING WATER SYSTEM
3.10 DOCUMENTATION, NON-CONFORMANCE, AND APPROVAL OF TESTS

A. Documentation:

1. The CxP witnesses and documents the results of all functional performance tests using forms developed for that purpose. Prior to testing, these forms are provided to the OPM for review and approval.

B. Non-Conformance:

1. The CxP records the results of the functional test on the procedure or test form. All deficiencies identified during the verification testing are documented on a standard Issues Log form and reported to the project manager, contractors, and sub-contractors. The deficiency report includes all details of the components or systems found to be non-compliant with the parameters of the test plans. The report details the adjustments or alterations required to correct system operation and identifies the responsible party.
2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxP. In such cases the deficiency and resolution will be documented on the procedure form.
3. Deficiencies that cannot be corrected during testing will be documented on the Issues Log and subject to retest. Retesting will continue until no deficiencies remain or by Owner's request.
4. Retesting is required when testing cannot be successfully completed. Deficiencies requiring include:
   a. Incomplete work and/or coordination with others.
   b. Inadequate preparation of systems for testing.
   c. Inadequate preplanning.
   d. Inadequate staff, equipment, tools or resources for testing.
   e. Material, equipment or construction deficiencies.
   f. Incomplete or failed test due to reasons under the Contractor's responsibility.
5. If there is a dispute about a deficiency or who is responsible:
   a. The deficiency is documented on the Issues Log and a copy given to the OPM and CM/GC.
   b. Resolutions are made at the lowest management level possible. Additional parties are brought into the discussions as needed. Final interpretive authority is with the A/E team. Final acceptance authority is with the Project Manager. The CxP documents the resolution process.
   c. Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency and notifies the CxP that the equipment is ready to be retested.
   d. The CxP reschedules the test and the test is repeated until satisfactory performance is achieved.

C. Cost of Retesting:

1. The cost of retesting is the responsibility of the contractor and subject to deductive change order. Correction of deficiencies and retesting are the responsibility of the contractor and are not subject to time extensions or delay claims.

D. Approval:

1. The CxP makes formal approval of the functional performance test after review. The CxP recommends acceptance of each test to the OPM. The OPM gives final approval on each test.
3.11  OWNER’S TRAINING
   A. Refer to Division 01 General Requirements and Section “Demonstration and Training” and relevant Division sections for requirements.
   B. The Contractor is responsible for developing a cohesive training plan for all Divisions and Sections of work where training is specified. See technical sections for specified minimum training hours for each component and system.
   C. The CM/GC shall provide the CxP a preliminary training plan and schedule related to the commissioned equipment to review and finalize incorporating comments received. The plan should include agendas including topics and objectives to be covered for each section, the instructor’s name and contact information, the anticipated duration and schedule for each session, a formal training record listing of attendees and a training evaluation form. Develop the training schedule including number of hours for each component or system in coordination with the CxP and CM that complies with the owner’s and CxP’s personnel availability.
   D. The CxP shall provide each trainee with a Training Evaluation Form and at completion of training collect forms for review. Based on evaluations and OPM training review, contractor shall repeat training sessions which were determined were inadequate or incomplete.

3.12  O&M DATA and CLOSEOUT SUBMITTALS
   A. Refer to Division 01 General Requirements and Section “Closeout Submittals” and relevant Division sections for requirements.
   B. The CM/GC shall provide the CxP closeout submittals related to the commissioned equipment to review and compile into a Recommissioning Systems Manual as required.

3.13  DEFERRED TESTING
   A. Unforeseen Deferred Tests: If any test cannot be completed due to the building structure, required occupancy condition, or other deficiency, the functional testing may be delayed upon approval of the OPM. These tests are conducted in the same manner as the seasonal tests as soon as possible.
   B. Seasonal Testing: Seasonal variation in operations or control strategies may require additional testing during the opposite season to verify performance of the HVAC system and controls. During the warranty period, seasonal testing and other deferred testing is completed as required to fully test all sequences of operation. The CxP coordinates these activities. Tests are executed and documented, with deficiencies corrected by the appropriate Subcontractors. Any final adjustments to the Operation and Maintenance manuals and as-buils due to the testing are also completed.

END OF SECTION 220800
SECTION 220900 – WATER MANAGEMENT FOR CONSTRUCTION

PART 1 - GENERAL

1.1 SECTION INCLUDES
   A. Water Management for Construction (WMC) Program
   B. Purpose: The contractor shall participate with the building owner during the construction phases of the project in establishing and implementing a water management for construction program as part of reducing the risk of spread and growth of *Legionella* and other waterborne pathogens using a risk management process per ANSI/ASHRAE Standard 188-2018 (or current version) entitled: Legionellosis: Risk Management for Building Water Systems.
   C. Water quality for *E.coli* and coliforms concerning fecal matter testing are not addressed in this specification section. The contractor must coordinate those activities with the specification sections for domestic plumbing water supply and disinfection procedures of the building distribution system.

1.2 RELATED SECTIONS
   A. Plumbing Water Service, Sections 22 00 00 to 22 50 00
   B. Civil Utility / Underground Water Supply & Main, Sections 33 00 00 to 33 40 00

1.3 DEFINITIONS
   ANSI – American National Standards Institute
   ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers
   AWWA – American Water Works Association
   CDC – Centers for Disease Control and Prevention
   CFU – colony forming units
   COC – Chain of Custody
   FRO – free residual oxidant measured in municipal water using chlorine disinfection
   HPC – heterotrophic plate count (total bacteria count)
   MG/L – milligrams per liter
   PFD – process flow diagram
   PPM – parts per million
   TRO – total residual oxidant measured in municipal water using chloramine disinfection
   THAB – total heterotrophic aerobic bacteria
   WMC – water management for construction
   US EPA – United States Environmental Protection Agency
1.4 QUALITY ASSURANCE / QUALITY CONTROL

A. WMC performed in accordance with ANSI/AHSRAE Standard 188
   1. Section 8.0 Requirements for Designing Building Water Systems
      a. Design Documents
      b. Final Installation Documents
      c. Balancing
      d. Commissioning

B. Validation Testing and Analytical Laboratory
   1. The contractor will cooperate, coordinate, and provide access to the project site by the Building Owner’s third-party vendor and analytical testing lab services throughout the duration of the project.
   2. Any services related to the validation sampling plan and testing for waterborne pathogens shall be performed by an independent third-party vendor with analytical laboratory specializing in waterborne pathogen testing experience and certification registered with the Centers for Disease Prevention and Control for Environmental Legionella Isolation Techniques Evaluation (ELITE). Cost and fees associated with validation sampling plan and the building owner’s desired validation test panel is the responsibility of the building owner. The quantities and sample locations for validation testing will be pre-determined for the project by the Owner based upon project scope, building type, occupancy type, number of floors, size of floor areas, piping distribution patterns and fixture types. Testing shall consist of:
      a. THAB (total heterotrophic aerobic bacteria)
      b. Next Day Legionella PCR™ Test for negative screen DNA detection
      c. Legionella ISO #11731 spread plate for detection limit of < 1 CFU/mL
      d. Temperature readings
      e. Residual oxidant readings using TRO or FRO (see definitions)
   3. Preferred Analytical Laboratory: (or pre-approved Owner alternate)
      Phigenics, LLC
      3S701 West Avenue, Suite 100
      Warrenville, IL 60555
      1-844-850-4087
      Phigenics Web Site: https://info.phigenics.com
   4. The contractor shall furnish properly trained, experienced, and/or certified personnel, appropriate equipment and materials, and disposal of treated water or chemical agents for all activities during water management for construction including municipal water, building piping distribution systems, and central plant utility systems. All such persons must be familiar with local, state, and federal guidelines, standards, and codes governing water quality and safety for building construction and operations.

1.5 REFERENCES

B. ASHRAE Guideline 12-2020 Managing the Risk of Legionellosis Associated with Building Water Systems
D. CDC Toolkit: Controlling Legionella in Common Sources of Exposure (Ver. 1/2021)
E. ANSI/AWWA C651 Disinfecting Water Mains
F. ANSI/AWWA C652 Disinfection of Water Storage Facilities
G. US EPA Drinking Water Requirements for States and Public Water Systems
H. US EPA Safe Drinking Water Act

1.6 DELIVERY, STORAGE, AND HANDLING OF DOCUMENTATION
A. Information for the WMC will be produced in the format of schedules, logs, reports, or forms as PDFs, spreadsheets, or other commonly available word processing media.
B. In addition to the WMC documentation manual assembled at project close out (see Section 3.5 Project Close-Out) all project information for the WMC documentation shall be input into the building owner’s preferred vendor’s web-based software to track and document information related to WMC activities. Any other documentation method for the WMC Program must be pre-approved by the building owner as an alternative documentation method.
C. All reports provided for water management for construction activities undertaken are to be documented on the corporate letterhead of the organization performing such activities for the project with relevant information such as, but not limited to: name of project, address of project, company performing the work, service performed, method of disinfection, dates and times (start and finish) of activities performed, extent and location of disinfection (i.e. building main, underground piping, risers, etc.), system flushing protocol (date and duration), validation sampling performed, location of samples marked on site/civil diagram, date and time validation samples were taken, analytical lab chosen to process samples, attachments of final independent analytical laboratory testing reports, the construction technician name responsible for performing the work, and technician signature line.

1.7 COORDINATION DRAWINGS
A. Use of the architectural composite floor plans and building water piping distribution plans for illustration of the sampling plan and validation test locations.

1.8 SUBMITTALS
A. Develop a water management for construction project schedule (in Gantt chart format using Microsoft Project, Smartsheet or other common construction project scheduling software program) inclusive of key dates for building construction activities:
   1. Building Water Distribution System Package
      a. Start date of building construction and/or tenant improvements for interior construction of spaces for future occupancy.
      b. Connection dates and activation dates related to point-of-entry water main.
      c. Identify dates related to supplemental disinfection system installation including owner furnished contractor installed potable water analyzer.
      d. Identify any temporary building water piping distribution
         1) Options to use temporary piping for bringing water to the construction site and building to be abandoned later; this can reduce the premature use of final building water distribution system to avoid bacterial overgrowth.
         2) Options to activate the building water system later in the project sequencing of work to avoid premature bacterial overgrowth in water piping distribution system.
      e. Activation of potable building water distribution system

WATER MANAGEMENT FOR CONSTRUCTION
1) Cold water distribution
2) Hot water distribution
3) Water heating system and storage
4) Implementation of flushing protocols for mains and branches
5) Preliminary disinfection of the potable building water distribution system (if any)

f. Installation of final plumbing fixtures
   1) Pressure testing
   2) Implementation of flushing protocols for terminal fixtures and devices
   3) Final disinfection of the potable building water distribution system (if any is required)

g. Building occupancy milestones
   1) Temporary occupancy certificate
   2) Substantial Completion
   3) Final beneficial occupancy
   4) First patient / resident / business day of operations

h. Validation Testing
   1) Potable water distribution system
      a) Identify test round dates
         i. Round #1 – water quality performance; schedule after water activation and before final disinfection
         ii. Round #2 – water safety performance; schedule after final disinfection and prior to beneficial occupancy
      b) Results dates
         i. Round #1 – before final disinfection
         ii. Round #2 – before beneficial occupancy
      i. Acceptance date of the building water quality and building water distribution system of the project for patient / resident care services between the contractor and the building owner.

2. Central Utility Plant Package
   a. Cooling Tower additions
   b. Cooling Tower start-up
   c. Cooling Tower validation sampling
      1) Test dates
      2) Results dates
   d. Acceptance date of the central plant water quality between the contractor and the building owner.
1.9 PRE-CONSTRUCTION CONFERENCE

A. Prior to the start of work, a conference meeting (attended by the Owner Representative(s), Contractor, M/P Engineer, and representatives from Enterprise Facility Services, Infection Prevention and Control, and the Froedtert Hospital Water Management Team, and others as deemed appropriate) will be conducted to establish the construction water management team to assist the contractor with decision making processes for achieving water safety and quality goals.

B. The established construction water management team shall establish the working understanding among the parties as to:

1. The work involved and how to implement the construction water management program per the specification sections included for the project
2. Review, confirm and approve the portion of work for the water management for construction project schedule per 1.8 Submittals, Item A
3. Establish the water management goals for the project including milestone dates to be met and agreed upon.
4. Determine communications for the WMC team.
5. Determine documentation methods for all WMC plan activities, logs, and reports.
6. Determine communications with local municipal water authority for the project.
7. Confirm municipal method of disinfection (i.e. chlorine or chloramines).
8. Establish a measured point-of-entry water TRO residual disinfectant level for the building to determine if water will be delivered in acceptable ranges for the water distribution system. Discuss and determine any plans for inclusion or exclusion of supplemental disinfection to maintain adequate residual disinfectant levels.
9. Determine flushing protocols (frequency and duration) to flush building water distribution system throughout the various stages and milestones of the project.
10. Determine the extent of final disinfection within the building piping distribution system for the project construction scope (i.e from building point-of-entry and/or select portions of the system).
11. Confirm building owner provided validation sampling plan, test types, quantities, and frequency of testing for each milestone (i.e. round) throughout the course of the project schedule.

PART 2 - PRODUCTS

2.1 EQUIPMENT / INSTRUMENTS /SUPPLIES

A. All standard test equipment to perform water testing shall be provided by the contractor and be calibrated within the past year in accordance with the manufacturer’s recommendations.

B. Instrument: Colorimeter, digital, measuring parameter for Chlorine free + total (such as Hach DR300 or industry equivalent).

C. Reagents: Colorimeter (foil powder pockets by colorimeter manufacturer or dispenser powder). Select the correct reagent per municipal water disinfectant method. Verify municipal water disinfectant is chloramine, use reagent for TRO. (example shown for dispenser powder)

1. 100 Test Sample Supplies (Small projects)
   a. Reagent (TRO) DPD#4 Dispenser for 10mL Sample, USABlueBook #34447
2. 1000 Test Sample Supplies (Large projects)
   a. Reagent (TRO) DPD#4 Dispenser for 10mL Sample, USABlueBook #34448
D. Calibration Gels: SpecCheck Secondary Gel Standards Set, DPD Chlorine compatible with instrument purchased to calibrate the instrument every six months to maintain accuracy of measurements.

E. Digital Thermometer: pocket temperature probe with digital readout, Range 0°F to 250°F (or c. -10°C to 120°C) (such as Hach Pocket Pro Temperature tester or industry equivalent).

PART 3 - EXECUTION

3.1 PREPARATION

A. Building Conditions: Examine areas and conditions under which the work is to be performed and identify conditions that may be detrimental to proper or timely completion of a water management for construction program, impacts to overall water quality, or water safety.

B. Water Activation is defined as any time when water is filled within any portion of the building water distribution system from the municipal building water point-of-entry to any other distribution point in the building (i.e. mains, branches, or terminal fixtures). This shall include all potential water fill conditions such as reuse of existing piping, draining and re-start-up conditions, and filling new piping with water. Example: if the contractor is using the building owner's piping distribution system (existing or new) for water use during construction activities for any reason this is considered an active water condition.

C. Flushing Protocol Activities: Unless otherwise directed by the building owner all flushing protocols will be implemented from start of water activation of the building water distribution system and continuously implemented through the first-patient day of operations until the building owner has formally accepted the project for on-going maintenance and operations.

3.2 FLUSHING PROTOCOLS

A. Flushing of Water Mains and Branch Distribution Lines During Construction Activities

1. Upon completion of work for installation of the permanent water distribution mains on the project, the following procedure will be performed to introduce fresh water with disinfectant residual into the completed plumbing distribution system mains and branches during construction.

2. All water drops are flushed with water to remove any foreign debris and tested in accordance with the specified pressures. Upon a successful test, the shut off valves will be shut off to each fixture/group of fixtures locking pressure in the respective lines to avoid potential issues during installation of subsequent finishes.

3. Respective access (i.e. tiles or access panels) to each valve will be coordinated with M/P contractor and the ceiling tile installation for regular access to these valves to minimize damage to final finished ceiling tiles or gypsum ceiling areas.

4. The contractor will flow water through each main or branch at a minimum weekly from the point of entry and continuing on the completed floors through strategic/remote fixtures. A flushing log documenting these events shall be maintained and completed to include: frequency of flushing (weekly), date, time of day, and flushing duration (number of minutes each location was flushed) and measure residual disinfectant concentrations at each flushing location.

5. The contractor will take a measurement using a colorimeter for residual disinfectant at each main or branch location, and readings will be kept in a WMC manual.
6. The minimum acceptable measurement for the residual disinfectant during flushing activities for this stage of the project shall be TRO 0.50 ppm (cold water lines). Should residuals not achieve 0.50 ppm the building owner should be consulted about reasons for lack of adequate disinfectant residual at mains and branches for the water distribution system.

7. Upon scheduled fixture installation for the respective floor(s), each valve(s) will be opened and each fixture drop will again be flushed prior to the installation of the final fixture trim as well as after the final components are installed to ensure no leak at each fixture.

8. Prior to final disinfection, all valves to fixtures will be re-opened and water run through each fixture for minimum of 5 minutes.

9. The entire domestic water system, or portions of the system (if required) will have a final disinfection process.

10. Assure Backflow prevention has been provided for all connections (e.g. temporary or final/permanent) to the domestic water system for use during construction.

B. Flushing Terminal Plumbing Fixtures After Installation

1. Routine flushing terminal fixture protocol will be established with the building owner with a frequency (number of days per week) and duration (amount of time per fixture, hot and cold) for water to be flushed through the system. This may include but are not limited to: terminal fixtures (e.g. sinks, showers), devices with water reservoirs (e.g. ice machines), water heaters, hot water recirculating loops, piping distribution branching, and the point-of-entry water main supply for the building.

2. The contractor will calculate the volume of the entire water piping distribution system and turn-over the entire volume of water with fresh water on a routine periodic basis. The minimum flushing frequency and durations established for this project are:
   
a. Frequency: Two-days per week on Monday and Thursday
b. Duration: 5 min. hot, followed by 5 min. cold

3. Flushing sequence should start from the most distal point on each floor and continue toward the plumbing water riser. Progress flushing from floors moving top to bottom and progressively toward the municipal building water main point-of-entry.

4. After each routine flushing event is performed, the contractor will use a colorimeter device to measure TRO (disinfectant) at a representative number (15%) of fixture locations per floor for both hot and cold-water distribution lines, the hot water return loop, and incoming building main.
   
a. Range TRO: 0.50 ppm -- 2.0 ppm hot water line
b. Range TRO: 0.50 ppm – 2.0 ppm cold water line
c. If residual disinfectant is less than designated for hot and cold, flush fixtures for an additional 5 minutes, and retake measurement(s). Repeat process until 0.50 ppm hot and cold residual disinfectant is obtained.
d. If TRO is not obtainable after repeated flushing events, the contractor shall notify and consult with the building owner and WMC Team for reasons about lack of adequate disinfectant residual at mains, branches, or terminal fixtures of the water distribution system.

5. After each routine flushing event is performed, the contractor will use a digital thermometer device to measure temperature of water at a representative number (15%) of fixture locations per floor for both hot and cold water distribution lines, the hot water return loop, and incoming building main.
   
a. Cold Water range: < 77°F
b. Hot Water range: ≥ 110°F and ≤ 125°F
c. Hot Water ranges must align with local authority having jurisdiction to minimize risk of scalding temperatures.
d. If point-of-use mixing valves are used, each mixing valve per fixture must be set, tested, and logged for alignment with temperature ranges for normal operating conditions.

6. Once the beneficial occupancy (substantial completion) disinfection of the building main and domestic water piping distribution system is completed, a routine flushing protocol of the system will be maintained by the contractor per the building owner’s water management for construction program until final completion and acceptance of the project as stated in Section 3.1.B.

7. Additional flushing and disinfection by the contractor maybe necessary:
   a. If beneficial occupancy of any part of the building is delayed more than two weeks (14 calendar days) but less than four weeks (28 calendar days) after disinfection, flushing of all fixtures shall again be completed per the building owner’s water management for construction program.
   b. If beneficial occupancy of any part of the building is delayed four weeks (28 calendar days) or more after disinfection, the need for disinfection and/or flushing for unoccupied areas shall be determined by the contractor and the building owner and WMC Team based upon risk assessment of the situation.

8. All disinfection and flushing events must be documented using written/printable logs and reports of all activities, protocols, events, and test results. Upon completion all records and logs are to be submitted to the building owner as part of verification of activities completed per the WMC Program.

3.3 DISINFECTION SCHEDULE FOR DOMESTIC WATER PIPING SYSTEMS

A. Disinfection of the domestic water piping distribution system shall be completed within three (3) weeks (21 calendar days) prior to building beneficial occupancy. Contractor is responsible for disinfecting water piping and distribution system if used by workers during construction; disinfection during construction does not eliminate the requirement for final disinfection prior to occupancy. Prior to proceeding with final disinfection, the building owner and WMC Team must be consulted to coordinate disinfection method and all activities with beneficial occupancy and project close out.

B. Perform final disinfection per local and state building codes (i.e. Wisconsin Administrative Code SPS382.40 through 50). Additionally, see Specification Section 22 08 00 Commissioning Plumbing Part 3 Section 3.7.

C. Disinfection of the domestic water piping distribution system shall be performed across the entire building water distribution system (hot and cold) including existing fixtures and new fixtures. The disinfection shall extend from the building or construction project point-of-entry, through all water main and branch distribution lines, all building risers, and to all terminal fixtures planned for use on every level of the construction project. If domestic water supply is connected to other occupied areas, the section for disinfection must be isolated with valves and proper backflow prevention. Review extent of locations, process, method, procedure, and impacted areas of disinfection with building owner and WMC Team for both occupied and unoccupied areas of the building prior to execution of all tasks associated with disinfection.

D. Following the designated hold time, the entire potable water system and all fixtures within the construction project shall be flushed with clean potable water until a TRO level of > 0.5 ppm and ≤ 4.0 ppm is achieved throughout the system to allow for safe drinking, patient care operations, and staff usage.
E. When validation testing is performed, the system must be at rest (non-usage) and/or operating under normal conditions for 24 hours without on-going purging or flushing activities prior to taking samples.

F. See Section 3.5 for Water Management Validation Testing of domestic water distribution system.

3.4 WATER MANAGEMENT VERIFICATION

A. The contractor shall participate in verification of the water management for construction program to assure the initial and on-going confirmation that the WMC Program is being implemented as designed.

B. The contractor will work with the building owner and WMC Team to provide confirmation in the form of information and documentation that:

1. All water management for construction operations and maintenance activities were being carried out as specified by designated personnel.

2. All activities are documented in logs, forms, or spreadsheet format acceptable by the building owner including but not limited to:

   a. Service or installation reports from water utility, plumbing or sub-trade professionals including water treatment vendors.

3.5 WATER MANAGEMENT VALIDATION TESTING

A. The contractor shall cooperate during activities for validation testing and validation response.

B. The contractor shall perform validation response during the water management for construction program to assure the WMC Program is effective as designed.

C. The contractor will provide access and cooperate with any notifications of the progress of construction work that may impact the validation sample collection process proceeding in a timely manner, including but not limited to delays in installation of terminal fixtures and devices with water reservoirs, building water mains and branches, risers, hot water storage or distribution systems, or cold water distribution systems.

D. Validation sample collection will be performed by third-party vendor and analytical laboratory and at the building owner’s cost and include:

1. Round #1 - Water Quality Performance Testing
   a. THAB < 10^4 CFU/mL
   b. Temperature:
      1) cold line - performance at fixtures (< 77°F)
      2) hot line - performance at fixtures (≥ 110°F)
   c. Residual Oxidant at fixtures (≥ 0.50 ppm and ≤ 4.0 ppm)

2. Round #2 - Water Safety Performance Testing
   a. PVT Next Day Legionella PCR™
      1) Non-detects considered acceptable – no further testing
      2) Detections will be followed up with Legionella ISO 11730
   b. Viable Legionella are < 1 CFU/mL
   c. THAB < 10^4 CFU/mL
   d. Temperature:
1) cold line performance at fixtures (< 77°F)
2) hot line performance at fixtures (> 110°F)

e. Residual Oxidant at fixtures (> 0.50 ppm and ≤ 4.0 ppm)

E. When validation test results are:

1. Within limits as defined, the system will be deemed acceptable:
   a. PVT Next Day Legionella PCR™
      1) Non-detects considered acceptable – no further microbial testing
      2) Detections will be followed up with Legionella ISO#11730
   b. Viable Legionella are < 1 CFU/mL
   c. THAB < 10^4 CFU/mL
   d. Temperature:
      1) cold line performance at fixtures (< 77°F)
      2) hot line performance at fixtures (> 110°F)
   e. Residual Oxidant at fixtures (> 0.50 ppm and ≤ 4.0 ppm)

2. When results are outside the designated range or above limits as defined above in Section 3.5.E.1, the system will be deemed unacceptable, and the contractor must perform validation response activities (i.e. additional flushing and/or disinfection protocols) prior to re-testing. Retesting must be completed using the same process and third-party vendor with analytical laboratory to assure comparable results. Responsibility of testing rounds are:
   a. Round #1 tests are responsibility of Owner
   b. First retest for each sample in Round #1 are responsibility of the Owner
   c. Second retest of each sample in Round #1 is responsibility of the Contractor
   d. Round #2 tests are responsibility of Owner
   e. First retest for each sample in Round #2 is responsibility of the Owner
   f. Second retest for each sample of Round #2 is responsibility of the Contractor
   g. All additional retests (i.e. third, fourth, fifth, etc.) per round of testing events are responsibility of the Contractor

3. The contractor will coordinate a meeting with the building owner and the water management construction team to determine validation response (i.e. additional flushing, disinfection protocols, or other control measures) if validation test results remain unacceptable after two rounds of Contractor retests.

3.6 PROJECT CLOSE-OUT

A. In addition to general project design documentation and as-builds for the building water distribution system, the building owner and WMC Team at any time can request any portion of final project documentation per ANSI/ASHRAE Standard 188; Section 8.2 Final Documents to resolve a WMC Program issue.

B. Project Close-Out Meeting

1. A conference meeting attended by the building owner, WMC Team, and contractor and others as deemed appropriate will be conducted to close the project.
2. Water safety tests are reviewed and accepted by the building owner and WMC Team.
3. All documentation performed under specification for the WMC Program including but not limited to reports, logs, schedules, and validation test results are given to the building owner and WMC Team in a manual identified as: Water Management for Construction Program Records.

END OF SECTION 220900
SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes domestic cold, hot and hot water circulation water piping inside the building, to a point of the first flange inside the building.

B. Site Civil contractor is responsible for installation of all exterior water piping into the building a minimum of 12" to a maximum of 18" to the first flange, including the mechanical seal.

C. Water meters will be furnished and installed by utility company, up to the size normally carried by the utility. Water meters over their normal size are to be supplied by the contractor. Contact local utilities for exact details.

D. Water meters will be furnished by utility company for installation by Contractor. This is the name and address of the Utility Company:


E. Related Sections include the following:

1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and fittings.
2. Division 22 Section "Domestic Water Piping Specialties" for water distribution piping specialties.
3. Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
4. Division 22 Section "Water Management for Construction."

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 22 Section "Basic Division 22 Requirements."

1.3 ACTION SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings and water meters.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Data:


B. Field Quality Control Test Reports.

1.5 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing domestic water piping systems with 125 psig, unless otherwise indicated.
1.6 QUALITY ASSURANCE
A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
B. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Basis of Design: Per the manufacturer listed.
B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

2.2 PIPING MATERIALS
A. Refer to Part 3 "Pipe and Fitting Applications" Article for applications of pipe, tube, fitting, and joining materials.
B. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.3 STEEL PIPE AND FITTINGS
A. Steel Pipe: ASTM A53/A 53M, Type [E] [S] [E or S], Grade [A] [B] [A or B], Schedule 40, galvanized. Include ends matching joining method.
   6. Steel-Piping, Grooved-End Fittings: ASTM A47/A 47M, galvanized, malleable-iron casting; ASTM A 106, galvanized steel pipe; or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
      a. Grooved-End-Pipe Couplings: AWWA C606, for steel-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.
   7. Steel Piping, Expansion Joints: Compound, galvanized steel fitting with telescoping body and slip-pipe section. Include packing rings, packing, limit rods, chrome-plated finish on slip-pipe sections, and flanged ends.
   8. Steel Piping, Double Expansion Joints: Compound, galvanized steel fitting with telescoping body and two slip-pipe sections. Include packing rings, packing, limit rods, chrome-plated finish on slip-pipe sections, and flanged ends.
2.4 STAINLESS STEEL PIPE AND FITTINGS

A. Stainless Steel Pipe: ASTM A270, ASTM A312, ASTM A450, ASTM A554, ASTM A778, ASME B36.19, Type [E] [S] [E or S], Grade [A] [B] [A or B], Schedule 10. Conforms to NSF 61 lead free standard. Include ends matching joining method.


2. Stainless Steel-Piping, Grooved-End Fittings and Couplings: ASTM A 536, with dimensions matching pipe.

2.5 COPPER TUBE AND FITTINGS

A. Soft Copper Tube: ASTM B 88, Types K and L, water tube, annealed temper.


2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Furnish Class 300 flanges if required to match piping.

3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

B. Hard Copper Tube: ASTM B 88, Type L, water tube, drawn temper.


2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Furnish Class 300 flanges if required to match piping.

3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

4. Copper, Grooved-End Fittings: ASTM B 75 copper tube or ASTM B 584 bronze castings.

a. Grooved-End-Tube Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, gasket suitable for hot water, and bolts and nuts.

C. Press Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Viega.
   b. Nibco.
   c. Elkhart Products Corporation.

2. Press Fitting: Copper press fittings shall conform to the material and sizing requirements of ASME B16.18 or ASME B16.22. O-rings for copper press fittings shall be EPDM.

3. Installing contractor shall provide the building owner with a pressing tool and a complete range of jaws for piping installed.

2.6 DUCTILE IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end, unless grooved or flanged ends are indicated.

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end, unless grooved or flanged ends are indicated.
   1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   2. Gaskets: AWWA C111, rubber.

C. Grooved-Joint Systems:
   1. Manufacturers:
      a. Victaulic Company.
      b. <Insert manufacturer's name>.
   3. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

D. Flanges: ASME 16.1, Class 125, cast iron.

2.7 PVC PIPE AND FITTINGS (CARRIER PIPE ONLY)

A. PVC Schedule 40 Pipe: ASTM D 1785.
   1. PVC Schedule 40 Fittings: ASTM D 2466, socket type.

2.8 VALVES

A. Bronze and cast-iron, general-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Balancing and drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."

2.9 WATER METERS

A. Displacement-Type Water Meters NPS 2 and Smaller: AWWA C700, nutating-disc totalization meter with bronze case and 150-psig minimum working-pressure rating; with registration in gallons or cubic feet as required by utility; and with threaded end connections.
   1. Meter Manufacturers:
      a. Badger Meter, Inc.
      b. Carlon Meter Company, Inc.
      d. Mueller Company.
      e. Schlumberger Limited; Water Div.
      f. Neptune Technology Group, Inc.
      g. Hersey Products, Inc.

B. Turbine-Type Water Meters: AWWA C701, totalization meter with 150-psig minimum working-pressure rating; with registration in gallons or cubic feet as required by utility; and with the following end connections.
1. NPS 2 and Smaller: Threaded.
2. NPS 2-1/2 and Larger: Flanged.
3. Available Manufacturers:
   a. ABB.
   b. Badger Meter, Inc.
   c. Hays Fluid Controls.
   e. Master Meter, Inc.
   f. McCrometer.
   g. Mueller Company.
   h. Schlumberger Limited; Water Div.
   i. SeaMetrics, Inc.
   j. Venture Measurement.

C. Compound-Type Water Meters NPS 3 and Larger: AWWA C702, totalization meter with integral main-line and bypass meters, bronze case, and 150-psig minimum working-pressure rating; with registration in gallons or cubic feet as required by utility; and with flanged end connections.

1. Available Manufacturers:
   a. ABB.
   b. Badger Meter, Inc.
   d. Master Meter, Inc.
   e. Mueller Company.
   f. Schlumberger Limited; Water Div.

D. Remote Registration System: Direct-reading type complying with AWWA C706; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility.

E. Remote Registration System: Encoder-type complying with AWWA C707; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility.

PART 3 - EXECUTION

3.1 EXCAVATION
   A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 PIPE AND FITTING APPLICATIONS
   A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.
   B. Flanges may be used on aboveground piping, unless otherwise indicated.
   C. Grooved joints may be used on aboveground grooved-end piping.
   D. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.
   E. Domestic Water Piping on Service Side of Water Meter inside the Building: Use the same piping material as indicated on the civil documents.
F. Under-Building-Slab, Domestic Water Piping on House Side of Water Meter, NPS 3 and Smaller: Soft copper tube, Type L; copper pressure fittings; and soldered joints.

G. Aboveground Potable Water Piping and/or Non-Potable Water Piping: Use the following piping materials for each size range:
   1. NPS 6 and Smaller: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
   2. NPS 2 to NPS 8: Hard copper tube, Type L with grooved ends; copper grooved-end fittings; grooved-end-tube couplings; and grooved joints.
   3. NPS 4 and Smaller: Hard copper tube ASTM B 88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.

H. Non-Potable-Water Piping: Use one of the following piping materials for each size range:
   1. NPS 3-1/2 and Smaller: Hard copper tube, Type L copper pressure fittings; and soldered joints.
   2. NPS 3-1/2 and Smaller: Hard copper tube, Type L with grooved ends; copper grooved-end fittings; grooved-end-tube couplings; and grooved joints.
   3. NPS 4 to NPS 6: Steel pipe; gray-iron, threaded fittings; and threaded joints.
   4. NPS 4 to NPS 6: Hard copper tube, Type L with grooved ends; copper grooved-end fittings; grooved-end-tube couplings; and grooved joints.
   5. NPS 8: Galvanized Steel pipe; gray-iron, threaded fittings; and threaded joints.
   6. NPS 8: Galvanized Steel pipe with grooved ends; steel-piping, grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
   7. NPS 8: Hard copper tube, Type L with grooved ends; copper grooved-end fittings; grooved-end-tube couplings; and grooved joints.

3.3 PIPING INSTALLATION

A. Basic piping installation requirements are specified in Division 22 Section "Basic Division 22 Requirements."

B. Install under-building-slab copper tubing according to CDA's "Copper Tube Handbook."

C. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Basic Division 22 Requirements."

D. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Wall penetration systems are specified in Division 22 Section "Basic Division 22 Requirements."

E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Pressure gages are specified in Division 22 Section "Meters and Gages for Plumbing Piping," and drain valves and strainers are specified in Division 22 Section "Domestic Water Piping Specialties."

F. Install water-pressure regulators downstream where indicated on the Drawings. Water-pressure regulators are specified in Division 22 Section "Domestic Water Piping Specialties."

G. Install domestic water piping level without pitch and plumb.

H. Rough-in domestic water piping for water meter installation according to utility company's requirements.

I. Install PEX piping with loop at each change of direction of more than 90 degrees where indicated on Drawings inside of carrier piping. Carrier piping to be PVC schedule 40.
3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Basic Division 22 Requirements."

B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

C. Grooved Joints: Assemble joints with grooved-end-pipe or grooved-end-tube coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

D. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

E. Press Connections: Copper press fittings shall be made in accordance with the manufacturer’s installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool approved by the manufacturer.

F. Joints for PEX Piping: Join according to ASTM F 1807.

G. For carrier piping Use long sweep PVC elbows.
   1. For a single inserted pipe the pipe size should be a minimum of 2 pipe diameters larger than the inserted pipe.
   2. For multiple inserted pipes carrier pipe should be a minimum of 4" in diameter.

3.5 WATER METER INSTALLATION

A. Rough-in domestic water piping and install water meters according to utility company’s requirements.

B. Water meters will be furnished by the plumbing contractor and installed per the utility company’s requirements.

C. Install water meters according to AWWA M6 as well as complying with the utility’s requirements.
   1. Install displacement-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.
   2. Install turbine-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.
   3. Install compound-type water meters with shutoff valves on water-meter inlet and outlet and on valved bypass around meter. Support meters, valves, and piping on brick or concrete piers.
   4. Install fire-service water meters with shutoff valves on water-meter inlet and outlet and on full-size valved bypass around meter. Support meter, valves, and piping on brick or concrete piers.
   5. Install remote registration system according to standards of utility and of authorities having jurisdiction.

3.6 HANGER AND SUPPORT INSTALLATION

A. Pipe hanger and support devices are specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to equipment and machines to allow service and maintenance.
C. Connect domestic water piping to exterior water-service piping at the first flange inside the building. Use transition and dielectric fittings to join dissimilar piping materials.
D. Connect domestic water piping to the following:
   1. Booster Pumps: Domestic Cold Water (DCW) suction and discharge piping.
   2. Water Heaters: Domestic Cold Water (DCW) supply and Domestic Hot Water (DHW) outlet piping in sizes indicated but not smaller than sizes of water heater connections.
   3. Plumbing Fixtures: DCW and DHW supply piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Plumbing Fixtures."
   4. Equipment: DCW and DHW supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger. Provide valved bypass for operation of system during service. Provide drain valve on drain connection.

3.8 FIELD QUALITY CONTROL

A. Inspect domestic water piping as follows:
   1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
   2. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
      a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
      b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
   3. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
   4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
B. Testing to be by third party vendors approved by the water management team.
C. Test domestic water piping as follows:
   1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
   2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four (4) hours. Leaks and loss in test pressure constitute defects that must be repaired.
5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.9 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
   a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
   b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.10 CLEANING

A. Clean and disinfect potable and non-potable domestic water piping as follows per the State of Wisconsin Plumbing Code and as referenced within 22 09 00:

1. Purge new piping and parts of existing domestic water piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures as described below:
   a. Flushing of Water Mains and Branch Distribution Lines During Construction Activities
      1) Upon completion of work for installation of the permanent water distribution mains on the project, the following procedure will be performed to introduce fresh water with disinfectant residual into the completed plumbing distribution system mains and branches during construction.
      2) All water drops are flushed with water to remove any foreign debris and tested in accordance with the specified pressures. Upon a successful test, the shut off valves will be shut off to each fixture/group of fixtures locking pressure in the respective lines to avoid potential issues during installation of subsequent finishes.
      3) Respective access (i.e. tiles or access panels) to each valve will be coordinated with M/P contractor and the ceiling tile installation for regular access to these valves to minimize damage to final finished ceiling tiles or gypsum ceiling areas.
4) The contractor will flow water through each main or branch at a minimum weekly from the point of entry and continuing on the completed floors through strategic/remote fixtures. A flushing log documenting these events shall be maintained and completed to include: frequency of flushing (weekly), date, time of day, and flushing duration (number of minutes each location was flushed) and measure residual disinfectant concentrations at each flushing location.

5) The contractor will take a measurement using a colorimeter for residual disinfectant at each main or branch location, and readings will be kept in a WMC manual.

6) The minimum acceptable measurement for the residual disinfectant during flushing activities for this stage of the project shall be TRO 0.50 ppm (cold water lines). Should residuals not achieve 0.50 ppm the building owner should be consulted about reasons for lack of adequate disinfectant residual at mains and branches for the water distribution system.

7) Upon scheduled fixture installation for the respective floor(s), each valve(s) will be opened and each fixture drop will again be flushed prior to the installation of the final fixture trim as well as after the final components are installed to ensure no leak at each fixture.

8) Prior to final disinfection, all valves to fixtures will be re-opened and water run through each fixture for minimum of 5 minutes.

9) The entire domestic water system, or portions of the system (if required) will have a final disinfection process.

10) Assure Backflow prevention has been provided for all connections (e.g. temporary or final/permanent) to the domestic water system for use during construction.

b. Flushing Terminal Plumbing Fixtures After Installation

1) Routine flushing terminal fixture protocol will be established with the building owner with a frequency (number of days per week) and duration (amount of time per fixture, hot and cold) for water to be flushed through the system. This may include but are not limited to: terminal fixtures (e.g. sinks, showers), devices with water reservoirs (e.g. ice machines), water heaters, hot water recirculating loops, piping distribution branching, and the point-of-entry water main supply for the building.

2) The contractor will calculate the volume of the entire water piping distribution system and turn-over the entire volume of water with fresh water on a routine periodic basis. The minimum flushing frequency and durations established for this project are:

   a) Frequency: Two-days per week on Monday and Thursday
   b) Duration: 5 min. hot, followed by 5 min. cold

3) Flushing sequence should start from the most distal point on each floor and continue toward the plumbing water riser. Progress flushing from floors moving top to bottom and progressively toward the municipal building water main point-of-entry.

4) After each routine flushing event is performed, the contractor will use a colorimeter device to measure TRO (disinfectant) at a representative number (15%) of fixture locations per floor for both hot and cold-water distribution lines, the hot water return loop, and incoming building main.

   a) Range TRO: 0.50 ppm -- 2.0 ppm hot water line
b) Range TRO: 0.50 ppm – 2.0 ppm cold water line

c) If residual disinfectant is less than designated for hot and cold, flush fixtures for an additional 5 minutes, and retake measurement(s). Repeat process until 0.50 ppm hot and cold residual disinfectant is obtained.

d) If TRO is not obtainable after repeated flushing events, the contractor shall notify and consult with the building owner and WMC Team for reasons about lack of adequate disinfectant residual at mains, branches, or terminal fixtures of the water distribution system.

5) After each routine flushing event is performed, the contractor will use a digital thermometer device to measure temperature of water at a representative number (15%) of fixture locations per floor for both hot and cold water distribution lines, the hot water return loop, and incoming building main.

a) Cold Water range: < 77°F
b) Hot Water range: > 110°F and < 125°F
c) Hot Water ranges must align with local authority having jurisdiction to minimize risk of scalding temperatures.

d) If point-of-use mixing valves are used, each mixing valve per fixture must be set, tested, and logged for alignment with temperature ranges for normal operating conditions.

6) Once the beneficial occupancy (substantial completion) disinfection of the building main and domestic water piping distribution system is completed, a routine flushing protocol of the system will be maintained by the contractor per the building owner’s water management for construction program until final completion and acceptance of the project as stated in Section 3.1.B.

7) Additional flushing and disinfection by the contractor maybe necessary:

a) If beneficial occupancy of any part of the building is delayed more than two weeks (14 calendar days) but less than four weeks (28 calendar days) after disinfection, flushing of all fixtures shall again be completed per the building owner’s water management for construction program.

b) If beneficial occupancy of any part of the building is delayed four weeks (28 calendar days) or more after disinfection, the need for disinfection and/or flushing for unoccupied areas shall be determined by the contractor and the building owner and WMC Team based upon risk assessment of the situation.

8) All disinfection and flushing events must be documented using written/printable logs and reports of all activities, protocols, events, and test results. Upon completion all records and logs are to be submitted to the building owner as part of verification of activities completed per the WMC Program.

B. Prepare and submit reports of purging and disinfecting activities.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

D. Before operating the system, perform these steps:

1. Close drain valve, hydrants, and hose bibs.
2. Open valves to fully open position.
3. Fill the system.
4. Remove and clean strainers.
5. Check pumps for proper direction of rotation. Correct improper wiring.
6. Lubricate pump motors and bearings.

END OF SECTION 221116
SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following domestic water piping specialties:
   1. Vacuum breakers.
   2. Backflow preventers.
   5. Temperature-actuated water mixing valves.
   7. Outlet boxes.
   8. Hose bibbs.
   9. Wall hydrants.
  10. Ground hydrants.
  11. Post hydrants.
  12. Drain valves.
  15. Miscellaneous Domestic Water Specialties.
B. Related Sections include the following:
   1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
   2. Division 22 Section "Domestic Water Piping" for water meters.

1.2 PERFORMANCE REQUIREMENTS
A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 22 Section "Basic Division 22 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.
B. Shop Drawings:
   1. Wiring Diagrams: Diagram power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.
1.6 QUALITY ASSURANCE

A. NSF Compliance:
   2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: Per the manufacturer listed.

B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

2.2 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Co.
      b. Cash Acme.
      c. Conbraco Industries, Inc.
      d. FEBCO; SPX Valves & Controls.
      e. Rain Bird Corporation.
      f. Toro Company (The); Irrigation Div.
      g. Watts Industries, Inc.; Water Products Div.
      h. Zurn Plumbing Products Group; Wilkins Div.
   3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
   5. Inlet and Outlet Connections: Threaded.
   6. Finish: Chrome plated.

B. Hose-Connection Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Arrowhead Brass Products, Inc.
      b. Cash Acme.
      c. Conbraco Industries, Inc.
      d. Legend Valve.
      e. MIFAB, Inc.
      f. Prier Products, Inc.
      g. Watts Industries, Inc.; Water Products Div.
      h. Woodford Manufacturing Company.
      i. Zurn Plumbing Products Group; Light Commercial Operation.
      j. Zurn Plumbing Products Group; Wilkins Div.

C. Pressure Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Co.
      b. Conbraco Industries, Inc.
      c. FEBCO; SPX Valves & Controls.
      d. Flomatic Corporation.
      e. Toro Company (The); Irrigation Div.
      g. Zurn Plumbing Products Group; Wilkins Div.
   3. Operation: Continuous-pressure applications.
   4. Pressure Loss: \[5 \text{ psig}] \text{ maximum, through middle 1/3 of flow range.}
   5. Size: \text{NPS.}
   6. Design Flow Rate: \text{gpm.}
   7. Selected Unit Flow Range Limits: \text{gpm.}
   8. Pressure Loss at Design Flow Rate: \text{psig.}
   9. Accessories:
      a. Valves: Ball type, on inlet and outlet.

D. Laboratory-Faucet Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
      c. Woodford Manufacturing Company.
      d. Zurn Plumbing Products Group; Wilkins Div.
   5. End Connections: Threaded.
   6. Finish: Chrome plated.

E. Spill-Resistant Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
   3. Operation: Continuous-pressure applications.
   4. Size: \text{NPS 1/2}, \text{NPS 3/4}, \text{NPS 1}.
   5. Accessories:
      a. Valves: Ball type, on inlet and outlet.
2.3 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cash Acme.
   b. Conbraco Industries, Inc.
   c. FEBCO; SPX Valves & Controls.
   d. Honeywell Water Controls.
   e. Legend Valve.
   g. Zurn Plumbing Products Group; Wilkins Div.

2. Standard: ASSE 1012.
3. Operation: Continuous-pressure applications.
4. Size: NPS 1/2 [NPS 3/4].
5. Body: Bronze.
7. Finish: Chrome plated

B. Reduced-Pressure-Principle Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ames Co.
   b. Conbraco Industries, Inc.
   c. FEBCO; SPX Valves & Controls.
   d. Flomatic Corporation.
   e. Watts Industries, Inc.; Water Products Div.
   f. Zurn Plumbing Products Group; Wilkins Div.

3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
5. Size: Insert NPS.
6. Design Flow Rate: Insert gpm
7. Selected Unit Flow Range Limits: Insert gpm
8. Pressure Loss at Design Flow Rate: Insert psig for sizes NPS 2 and smaller; Insert psig for NPS 2-1/2 and larger.
9. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved; steel with interior lining complying with AWWA C550 or that is FDA approved; stainless steel for NPS 2-1/2 and larger.
10. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
11. Configuration: Designed for horizontal, straight through; vertical inlet, horizontal center section, and vertical outlet; vertical flow.
12. Accessories:
   a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
C. Double-Check Backflow-Prevention Assemblies:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Co.
      b. Conbraco Industries, Inc.
      c. FEBCO; SPX Valves & Controls.
      d. Flomatic Corporation.
      e. Watts Industries, Inc.; Water Products Div.
      f. Zurn Plumbing Products Group; Wilkins Div.
   3. Operation: Continuous-pressure applications, unless otherwise indicated.
   4. Pressure Loss: \([5 \text{ psig}] <\text{Insert pressure}> \) maximum, through middle 1/3 of flow range.
   5. Size: <Insert NPS.>
   7. Selected Unit Flow Range Limits: <Insert gpm.>
   8. Pressure Loss at Design Flow Rate: <Insert psig > for sizes NPS 2 and smaller; <Insert psig > for NPS 2-1/2 and larger.
   9. Body: Bronze for NPS 2 and smaller; [cast iron with interior lining complying with AWWA C550 or that is FDA approved] [steel with interior lining complying with AWWA C550 or that is FDA approved] [stainless steel] for NPS 2-1/2 and larger.
   10. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   11. Configuration: Designed for horizontal, straight through flow.
   12. Accessories:
      a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

D. Beverage-Dispensing-Equipment Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
      c. Zurn Plumbing Products Group; Wilkins Div.
   3. Operation: Continuous-pressure applications.

E. Dual-Check-Valve Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cash Acme.
      b. Conbraco Industries, Inc.
      c. FEBCO; SPX Valves & Controls.
      d. Flomatic Corporation.
      e. Ford Meter Box Company, Inc. (The).
      f. Honeywell Water Controls.
g. Legend Valve.
h. McDonald, A. Y. Mfg. Co.
i. Mueller Co.; Water Products Div.
k. Zurn Plumbing Products Group; Wilkins Div.

3. Operation: Continuous-pressure applications.
4. Size: [NPS 1/2] [NPS 3/4] [NPS 1] [NPS 1-1/4].
5. Body: Bronze with union inlet.

F. Carbonated-Beverage-Dispenser, Dual-Check-Valve Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cash Acme.
   b. Lancer Corporation.

3. Operation: Continuous-pressure applications.

G. Reduced-Pressure-Detector, Fire-Protection Backflow-Preventer Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ames Co.
   b. Conbraco Industries, Inc.
   c. FEBCO; SPX Valves & Controls.
   e. Zurn Plumbing Products Group; Wilkins Div.

2. Standard: ASSE 1047 and UL Listed.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
5. Size: <Insert NPS.>
7. Selected Unit Flow Range Limits: <Insert gpm.>
8. Pressure Loss at Design Flow Rate: <Insert psig.>
9. Body: [Cast iron with interior lining complying with AWWA C550 or that is FDA approved] [Steel with interior lining complying with AWWA C550 or that is FDA approved] [Stainless steel].
11. Configuration: Designed for [horizontal, straight through] [vertical inlet, horizontal center section, and vertical outlet] [vertical] > flow.
12. Accessories:
   a. Valves: Outside screw and yoke gate-type with flanged ends on inlet and outlet.
   c. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.
H. Double-Check, Detector-Assembly Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Co.
      b. Conbraco Industries, Inc.
      c. FEBCO; SPX Valves & Controls.
      e. Zurn Plumbing Products Group; Wilkins Div.
   2. Standard: ASSE 1048 and UL Listed.
   3. Operation: Continuous-pressure applications.
   4. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
   5. Size: <Insert NPS.> 
   7. Selected Unit Flow Range Limits: <Insert gpm.> 
   8. Pressure Loss at Design Flow Rate: <Insert psig.> 
   9. Body: [Cast iron with interior lining complying with AWWA C550 or that is FDA approved] [Steel with interior lining complying with AWWA C550 or that is FDA approved] [Stainless steel].
   11. Configuration: Designed for [horizontal, straight through] [vertical inlet, horizontal center section, and vertical outlet] [vertical] flow.
   12. Accessories:
      a. Valves: Outside screw and yoke gate-type with flanged ends on inlet and outlet.
      b. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

I. Hose-Connection Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
      c. Woodford Manufacturing Company.
   3. Operation: Up to 10-foot head of water back pressure.
   4. Inlet Size: NPS 1/2 or NPS 3/.
   5. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
   6. Capacity: At least 3-gpm flow.

J. Backflow-Preventer Test Kits:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
      b. FEBCO; SPX Valves & Controls.
      c. Flomatic Corporation.
      e. Zurn Plumbing Products Group; Wilkins Div.
2. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.4 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cash Acme.
      b. Conbraco Industries, Inc.
      c. Honeywell Water Controls.
      e. Zurn Plumbing Products Group; Wilkins Div.
   3. Pressure Rating: Initial working pressure of 150 psig (1035 kPa).
   4. Size: <Insert NPS.>
   5. Design Flow Rate: <Insert gpm.>
   8. Body: Bronze with chrome-plated finish for NPS 2 and smaller; cast iron [with interior lining complying with AWWA C550 or that is FDA approved] for NPS 2-1/2 and NPS 3.
   10. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

B. Water Control Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CLA-VAL Automatic Control Valves.
      b. Flomatic Corporation.
      c. OCV Control Valves.
      e. Watts Industries, Inc.; Watts ACV.
      f. Zurn Plumbing Products Group; Wilkins Div.
   2. Description: Pilot-operation, diaphragm-type, single-seated main water control valve.
   3. Pressure Rating: Initial working pressure of 150 psig (1035 kPa) minimum with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot-control valve, restrictor device, specialty fittings, and sensor piping.
   4. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
      a. Size: <Insert NPS.>
      b. Pattern: Angle-valve design.
      c. Trim: Stainless steel.
   8. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
2.5 BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Flo Fab Inc.
      c. ITT Industries; Bell & Gossett Div.
      d. NIBCO INC.
      e. TAC Americas.
      f. Taco, Inc.
      g. Watts Industries, Inc.; Water Products Div.
   2. Type: Ball valve with two readout ports and memory setting indicator.
   3. Body: [Brass] [or] [bronze].
   4. Size: Same as connected piping, but not larger than NPS 2.
   5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. Memory-Stop Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
      b. Crane Co.; Crane Valve Group; Crane Valves.
      c. Crane Co.; Crane Valve Group; Jenkins Valves.
      d. Crane Co.; Crane Valve Group; Stockham Div.
      e. Hammond Valve.
      f. Milwaukee Valve Company.
      g. NIBCO INC.
      h. Red-White Valve Corp.
   2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
   3. Pressure Rating: 400-psig (2760-kPa) minimum CWP.
   4. Size: NPS 2 (DN 50) or smaller.
   5. Body: Copper alloy.
   6. Port: Standard or full port.
   7. Ball: Chrome-plated brass.
   8. Seats and Seals: Replaceable.
   9. End Connections: Solder joint or threaded.

2.6 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Water-Temperature Limiting Devices:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Cash Acme.
      c. Conbraco Industries, Inc.
      d. Honeywell Water Controls.
      e. Legend Valve.
      f. Leonard Valve Company.
g. Powers; a Watts Industries Co.

h. Symmons Industries, Inc.

i. Taco, Inc.


k. Zurn Plumbing Products Group; Wilkins Div.


4. Type: Thermostatically controlled water mixing valve.

5. Material: Bronze body with corrosion-resistant interior components.

6. Connections: Threaded union inlets and outlet.

7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.

8. Tempered-Water Setting: Insert ° F.

9. Tempered-Water Design Flow Rate: 

10. Valve Finish: Chrome plated.

B. Primary, Thermostatic, Water Mixing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:


   b. Lawler Manufacturing Company, Inc.

   c. Leonard Valve Company.

   d. Powers; a Watts Industries Co.

   e. Symmons Industries, Inc.


4. Type: [Exposed-mounting] [Cabinet-type], thermostatically controlled water mixing valve.

5. Material: Bronze body with corrosion-resistant interior components.

6. Connections: Threaded union inlets and outlet.

7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.

8. Valve Pressure Rating: 125 psig minimum, unless otherwise indicated.

9. Tempered-Water Setting: <Insert ° F.>


11. Selected Valve Flow Rate at 45-psig (310-kPa) Pressure Drop: <Insert gpm.>

12. Pressure Drop at Design Flow Rate: <Insert psig.>

13. Valve Finish: [Chrome plated] [Polished, chrome plated] [Rough bronze].

14. Piping Finish: [Chrome plated] [Copper].

15. Cabinet: Factory-fabricated, stainless steel, for [recessed] [surface] mounting and with hinged, stainless-steel door.

C. Manifold, Thermostatic, Water-Mixing-Valve Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Leonard Valve Company.

   b. Powers; a Watts Industries Co.

   c. Symmons Industries, Inc.
2. Description: Factory-fabricated, [cabinet-type] [exposed-mounting], thermostatically controlled, water-mixing-valve assembly in [two] [three]-valve parallel arrangement.

3. Large-Flow Parallel: Thermostatic water mixing valve and downstream pressure regulator with pressure gages on inlet and outlet.


6. Thermostatic Mixing Valves: Comply with ASSE 1017. Include check stops on hot- and cold-water inlets and shutoff valve on outlet.

7. Water Regulator(s): Comply with ASSE 1003. Include pressure gage on inlet and outlet.

8. Component Pressure Ratings: 125 psig minimum, unless otherwise indicated.


11. Tempered-Water Setting: <Insert ° F.>

12. Unit Tempered-Water Design Flow Rate: <Insert gpm.>


14. Selected Unit Flow Rate at 45-psi (310-kPa) Pressure Drop: <Insert gpm.>

15. Unit Pressure Drop at Design Flow Rate: <Insert psig.>

16. Unit Tempered-Water Outlet Size: <Insert NPS > end connection.

17. Unit Hot- and Cold-Water Inlet Size: <Insert NPS > end connections.

18. Thermostatic Mixing Valve and Water Regulator Finish: [Chrome plated] [Polished, chrome plated] [Rough bronze].

19. Piping Finish: [Chrome plated] [Copper].

D. Photographic-Process, Thermostatic, Water-Mixing-Valve Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Lawler Manufacturing Company, Inc.
   b. Leonard Valve Company.
   c. Powers; a Watts Industries Co.
   d. Symmons Industries, Inc.

2. Standard: ASSE 1017, thermostatically controlled water mixing valve made for precise, process-water temperature control.

3. Pressure Rating: 125 psig minimum, unless otherwise indicated.


5. Connections: Threaded inlet and outlet.

6. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, thermometer, shutoff valve, and adjustable, temperature-control handle.

7. Cabinet: Factory-fabricated, stainless steel, for surface mounting; with controls and thermometer mounted on front.

8. Tempered-Water Setting: <Insert ° F.>


10. Tempered-Water Outlet Size: <Insert NPS > end connection.

11. Hot- and Cold-Water Inlet Size: <Insert NPS > end connections.

E. Individual-Fixture, Water Tempering Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cash Acme.

DOMESTIC WATER PIPING SPECIALTIES

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b. Conbraco Industries, Inc.
c. Honeywell Water Controls.
d. Lawer Manufacturing Company, Inc.
e. Leonard Valve Company.
f. Powers; a Watts Industries Co.
g. Watts Industries, Inc.; Water Products Div.
h. Zurn Plumbing Products Group; Wilkins Div.

3. Pressure Rating: 125 psig minimum, unless otherwise indicated.
5. Temperature Control: Adjustable.
6. Inlets and Outlet: Threaded.
7. Finish: Rough or chrome-plated bronze.
8. Tempered-Water Setting: <Insert ° F.>
9. Tempered-Water Design Flow Rate: <Insert gpm>

F. Primary Water Tempering Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Leonard
   c. Powers

2. Standard: ASSE 1017, thermostatically controlled tempering valve, listed as tempering valve.
3. Pressure Rating: 125 psig minimum, unless otherwise indicated.
6. Inlets and Outlet: Threaded.
7. Selected Primary Water Tempering Valve Size: <Insert size.>
8. Tempered-Water Setting: <Insert ° F.>
11. Tempered-Water Outlet Size: <Insert NPS> end connection.
12. Cold-Water Inlet Size: <Insert NPS> end connection.

G. Electronic Primary Water Tempering Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong Brain.
   b. Powers Intellistation.

2. Standard: ASSE 1017, thermostatically controlled tempering valve, listed as tempering valve.
3. Pressure Rating: 125 psig minimum, unless otherwise indicated.
4. Body: Bronze or stainless steel with factory-constructed manifold.
5. Temperature Control: Electronic with BAS interface.
7. Selected Primary Water Tempering Valve Size: <Insert size.>
8. Tempered-Water Setting: <Insert ° F.>
11. Tempered-Water Outlet Size: <Insert NPS > end connection.
12. Cold-Water Inlet Size: <Insert NPS > end connection.

2.7 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:
   1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
   2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 and larger.
   3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   4. Screen: Stainless steel with round perforations, unless otherwise indicated.
   5. Perforation Size:
      a. Strainers NPS 2 and Smaller: [0.020 inch] [0.033 inch] [0.062 inch].
      b. Strainers NPS 2-1/2 to NPS 4: [0.045 inch] [0.062 inch] [0.125 inch].
      c. Strainers NPS 5 (DN 125) and Larger: [0.10 inch] [0.125 inch] [0.25 inch].
   6. Drain: [Pipe plug] [Factory-installed, hose-end drain valve].

2.8 OUTLET BOXES

A. Clothes Washer Outlet Boxes:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Guy Gray Manufacturing Co., Inc.
      c. IPS Corporation.
      d. LSP Products Group, Inc.
      e. Oatey.
      f. Plastic Oddities; a division of Diverse Corporate Technologies.
      g. Symmons Industries, Inc.
      h. Watts Industries, Inc.; Water Products Div.
      i. Whitehall Manufacturing; a div. of Acorn Engineering Company.
      j. Zurn Plumbing Products Group; Light Commercial Operation.
   3. Material and Finish: [Enameled-steel or epoxy-painted-steel] [Enameled-steel or epoxy-painted-steel or plastic] [Plastic] [Stainless-steel] box and faceplate with optional integral water hammer arrestor.
   4. Faucet: Combination, valved fitting or separate hot- and cold-water, valved fittings complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.
   5. Supply Shutoff Fittings: NPS 1/2 gate, globe, or ball valves and NPS 1/2 copper, water tubing.
   6. Drain: [NPS 1-1/2] [NPS 2] standpipe and P-trap for direct waste connection to drainage piping.
7. Inlet Hoses: Two 60-inch long, rubber household clothes washer inlet hoses with female, garden-hose-thread couplings. Include rubber washers.
8. Drain Hose: One 48-inch long, rubber household clothes washer drain hose with hooked end.

B. Icemaker Outlet Boxes:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. IPS Corporation.
   c. LSP Products Group, Inc.
   d. Oatey.
   e. Plastic Oddities; a division of Diverse Corporate Technologies.
3. Material and Finish: [Enamed steel or epoxy-painted-steel] [Enamed steel or epoxy-painted steel or plastic] [Plastic] [Stainless steel] box and faceplate with optional integral water hammer arrestor.
4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
5. Supply Shutoff Fitting: NPS 1/2 ball valve and NPS 1/2 copper, water tubing.

2.9 HOSE BIBBS
A. Hose Bibbs:
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
10. Finish for Finished Rooms: Chrome or nickel plated.
14. Include operating key with each operating-key hose bibb.
15. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.10 WALL HYDRANTS
A. Non-freeze Wall Hydrants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. MIFAB, Inc.
   c. Prier Products, Inc.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounting with cover.
12. Operating Keys(s): Two with each wall hydrant.

B. Non-freeze, Hot- and Cold-Water Wall Hydrants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Prier Products, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Woodford Manufacturing Company.
   g. Zurn Plumbing Products Group; Specification Drainage Operation.
4. Operation: Loose key.
5. Casings and Operating Rods: Of length required to match wall thickness. Include wall clamps.
7. Outlet: Concealed.
8. Box: Deep, flush mounting with cover.
11. Operating Keys(s): Two with each wall hydrant.

2.11 GROUND HYDRANTS
A. Non-freeze, Ground Hydrants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
b. MIFAB, Inc.
c. Murdock, Inc.
d. Prier Products, Inc.
e. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
f. Tyler Pipe; Wade Div.
g. Watts Drainage Products Inc.
h. Woodford Manufacturing Company.
i. Zurn Plumbing Products Group; Light Commercial Operation.
j. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.21.3M.
3. Type: Nonfreeze, concealed-outlet ground hydrant with box.
4. Operation: Loose key.
5. Casing and Operating Rod: Of at least length required for burial of valve below frost line.
8. Drain: Designed with hole to drain into ground when shut off.
11. Operating Key(s): Two with each ground hydrant.

2.12 POST HYDRANTS
A. Non-freeze, Draining-Type Post Hydrants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. MIFAB, Inc.
   b. Prier Products, Inc.
   c. Simmons Manufacturing Co.
   e. Tyler Pipe; Wade Div.
   f. Watts Drainage Products Inc.
   g. Woodford Manufacturing Company.
   h. Zurn Plumbing Products Group; Light Commercial Operation.
   i. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.21.3M.
3. Type: Non-freeze, exposed-outlet post hydrant.
4. Operation: Loose key.
5. Casing and Operating Rod: Of at least length required for burial of valve below frost line.
9. Drain: Designed with hole to drain into ground when shut off.
10. Vacuum Breaker: Nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011; and garden-hose thread complying with ASME B1.20.7 on outlet.
11. Operating Key(s): Two with each loose-key-operation wall hydrant.
B. Freeze-Resistant Sanitary Yard Hydrants:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hoeptner Products.
   2. Standard: ASSE 1057, Type 5 for nondraining hydrants.
   3. Operation: Wheel handle.
   4. Head: Copper alloy, with pail hook.
   5. Inlet: NPS 3/4-inch (DN 20) threaded inlet and inlet nozzle, galvanized-steel riser, and venturi.

2.13 DRAIN VALVES
   A. Ball-Valve-Type, Hose-End Drain Valves:
      2. Pressure Rating: 400-psig minimum CWP.
      4. Body: Copper alloy.
      5. Ball: Chrome-plated brass.
      8. Inlet: Threaded or solder joint.

2.14 WATER HAMMER ARRESTERs
   A. Water Hammer Arresters:
      1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         a. AMTROL, Inc.
         b. Josam Company.
         c. MIFAB, Inc.
         d. PPP Inc.
         e. Sioux Chief Manufacturing Company, Inc.
         g. Tyler Pipe; Wade Div.
         h. Watts Drainage Products Inc.
         i. Zurn Plumbing Products Group; Specification Drainage Operation.
      3. Type: Copper tube with piston.
      4. Size: 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.
      5. Provide minimum of a 6 inch by 8 inch Access Panel to general contractor for installation.
2.15 AIR VENTS
   A. Bolted-Construction Automatic Air Vents:
      1. Body: Bronze.
      2. Pressure Rating: 125-psig minimum pressure rating at 140 ° F.
      3. Float: Replaceable, corrosion-resistant metal.
      5. Size: NPS 1/2 minimum inlet.

2.16 MISCELLANEOUS DOMESTIC WATER SPECIALTIES
   A. Neptune Waste Management System Docking Station Thermostatic Mixing Valve:
      1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         a. Leonard
         b. Powers
         c. Watts
      3. Pressure Rating: 125 psig minimum, unless otherwise indicated.
      6. Inlets and Outlet: Threaded or sweat.
      7. Selected Primary Water Tempering Valve Size: <Insert size.>
      8. Tempered-Water Setting: <Insert F.>
     11. Tempered-Water Outlet Size: <Insert NPS> end connection.
     12. Cold-Water Inlet Size: <Insert NPS> end connection.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Refer to Division 22 Section "Basic Division 22 Requirements" for piping joining materials, joint construction, and basic installation requirements.
   B. Install backflow preventers in each water supply to medical equipment, mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
      1. Locate backflow preventers in same room as connected equipment or system.
      2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to be centered over floor drain with funnel. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
      3. Do not install bypass piping around backflow preventers.
C. Install water regulators with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.

D. Install water control valves with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.

E. Install balancing valves in locations where they can easily be adjusted with a minimum flow of 1 gallon per minute per valve.

F. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
   1. Install thermometers and water regulators if specified.
   2. Install cabinet-type units recessed in or surface mounted on wall as specified.

G. Install Y-pattern strainers for water on supply side of each [control valve,] [water pressure-reducing valve,] [solenoid valve,] [and pump].

H. Install outlet boxes recessed in wall. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 06 Section "Rough Carpentry." Install water hammer arrestor on supply branches if not included with outlet box.

I. Install hose stations with check stops or shutoff valves on inlets and with thermometer on outlet.
   1. Install shutoff valve on outlet if specified.
   2. Install cabinet-type units recessed in or surface mounted on wall as specified. Install 2-by-4-inch (38-by-89-mm) fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 06 Section "Rough Carpentry."

J. Install ground hydrants with 1 cu. yd. of crushed gravel around drain hole. Set ground hydrants with box flush with grade.

K. Install draining-type post hydrants with 1 cu. yd. of crushed gravel around drain hole. Set post hydrants in concrete paving or in 1 cu. ft. of concrete block at grade.

L. Install nonfreeze, nondraining-type post hydrants set in concrete or pavement.

M. Install freeze-resistant yard hydrants with riser pipe set in concrete or pavement. Do not encase canister in concrete.

N. Install water hammer arresters in water piping according to PDI-WH 201.

O. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

B. Ground equipment according to Division 26 Section "Grounding and Bonding."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
1. Pressure vacuum breakers.
2. Intermediate atmospheric-vent backflow preventers.
3. Reduced-pressure-principle backflow preventers.
5. Carbonated-beverage-machine backflow preventers.
7. Reduced-pressure-detector, fire-protection backflow-preventer assemblies.
10. Calibrated balancing valves.
11. Primary, thermostatic, water mixing valves.
13. Primary water tempering valves.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section “Identification for Plumbing Piping and Equipment.”

3.4 FIELD QUALITY CONTROL
   A. Perform the following tests and prepare test reports:
      1. Test each pressure vacuum breaker, reduced-pressure-principle backflow preventer, double-check backflow-prevention assembly, and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device’s reference standard.
   B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.5 ADJUSTING
   A. Set field-adjustable pressure set points of water pressure-reducing valves.
   B. Set field-adjustable flow set points of balancing valves.
   C. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

END OF SECTION 221119
SECTION 221123 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes the following all-bronze and bronze-fitted centrifugal pumps for domestic cold- and hot-water circulation:
      2. Close-coupled, horizontally mounted, in-line centrifugal pumps.
      4. Variable speed booster pumps.

1.2 SUBMITTALS
   A. General: Submit the following in accordance with Division 22 Section "Basic Division 22 Requirements."

1.3 ACTION SUBMITTALS
   A. Product Data: For each type and size of domestic water pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.
   B. Shop Drawings:
      1. Wiring Diagrams: Diagram power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For domestic water pumps to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE
   A. Product Options: Drawings are to indicate size, profiles, and dimensional requirements of domestic water pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
   B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   C. UL Compliance: Comply with UL 778 for motor-operated water pumps.
   D. Hydraulic Institute Compliance: Design manufacture and install plumbing pumps in accordance with "Hydraulic Institute Standards."
   E. NEMA compliance: Electric motors and components shall be listed and labeled NEMA.
   F. Single-Source Responsibility: Obtain plumbing pumps of the same type from a single manufacturer.

1.6 DELIVERY, STORAGE, AND HANDLING
   A. Retain shipping flange protective covers and protective coatings during storage.
   B. Protect bearings and couplings against damage.
C. Comply with pump manufacturer's written rigging instructions for handling.

1.7 COORDINATION
A. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Basis of Design: Per the manufacturer listed.
B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.
C. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CLOSE COUPLED, IN-LINE, SEALLESS CENTRIFUGAL PUMPS
A. Manufacturers:
   1. Armstrong Pumps Inc.
   2. Bell & Gossett Domestic Pump; ITT Industries.
   3. Grundfos Pumps Corp.
   4. Taco, Inc.
B. Description: Factory-assembled and -tested, single-stage, close-coupled, in-line, sealless centrifugal pumps as defined in HI 5.1-5.6.
   1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge-type unit with motor and impeller on common shaft and designed for installation with pump and motor shaft mounted horizontally. Pump shall be rated for 125 psig working pressure and 225 deg. F continuous water temperature.
   2. Casing: Bronze, with threaded companion-flange connections.
   3. Impeller: Corrosion-resistant material.
   4. Motor: Single speed, unless otherwise indicated. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

2.3 SEPARATELY COUPLED, IN-LINE CENTRIFUGAL PUMPS
A. Manufacturers:
   1. Armstrong Pumps Inc.
   2. Bell & Gossett Domestic Pump; ITT Industries.
   3. Grundfos Pump Corp.
   4. Taco, Inc.
   5. Weinman Div.; Crane Pumps & Systems.
B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; and designed for installation with pump and motor shafts mounted horizontally. Pump shall be rated for 125 psig working pressure and 225 deg. F continuous water temperature.
1. **Pump Construction:** Bronze fitted
   a. **Casing:** Radially split bronze, with threaded companion-flange connections.
   b. **Impeller:** 316 Stainless steel, keyed to shaft.
   c. **Shaft and Shaft Sleeve:** Steel shaft, with copper-alloy shaft sleeve.
   d. **Seal:** Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
   e. **Bearings:** Oil-lubricated; bronze-journal or ball type.

2. **Shaft Coupling:** Flexible, capable of absorbing torsional vibration and shaft misalignment.

3. **Motor:** Single speed, with oil-lubricated bearings, unless otherwise indicated; and resiliently mounted to pump casing. Comply with requirements in Division 22 Section “Common Motor Requirements for Plumbing Equipment.”

### 2.4 CLOSE-COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

#### A. Manufacturers:
1. Armstrong Pumps Inc.
2. Bell & Gossett Domestic Pump; ITT Industries.
3. Grundfos Pump Corp.
4. Little Giant Pump
6. Paco Pumps, Inc.
7. Thrush Company, Inc.

#### B. Description: Factory-assembled and -tested, overhung impeller, single-stage, close-coupled, horizontally mounted, in-line centrifugal pumps as defined in HI 1.1-1.2 and HI 1.3; and designed for installation with pump and motor shafts mounted horizontally. Pump shall be rated for 175 psig working pressure and 225 deg. F continuous water temperature.

1. **Pump Construction:** Bronze fitted.
   a. **Casing:** Radially split, cast iron, with threaded companion-flange connections for pumps with NPS 2 pipe connections and flanged connections for pumps with NPS 2-1/2 pipe connections.
   b. **Impeller:** 316 Stainless Steel; statically and dynamically balanced, closed, and keyed to shaft.
   c. **Shaft and Shaft Sleeve:** Steel shaft, with copper-alloy shaft sleeve.
   d. **Seal:** Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
   e. **Bearings:** Oil-lubricated; bronze-journal or ball type.

2. **Shaft Coupling:** Rigid type if pump is provided with coupling.

3. **Motor:** Single speed, with grease-lubricated ball bearings. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

### 2.5 CLOSE-COUPLED, VERTICALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

#### A. Manufacturers:
1. Alyan Pump Company.
2. Armstrong Pumps Inc.
3. Aurora Pump; Pentair Pump Group (The).
4. Bell & Gossett Domestic Pump; ITT Industries.
5. Federal Pump Corp.
6. Grundfos Pumps Corp.
8. Paco Pumps, Inc.
10. Taco, Inc.
11. Thrush Company, Inc.

B. Description: Factory-assembled and -tested, overhung impeller, single-stage, close-coupled, vertically mounted, in-line centrifugal pumps as defined in HI 1.1-1.2 and HI 1.3; and designed for installation with pump and motor shafts mounted vertically. Pump shall be rated for 125 psig working pressure and 225 deg. F continuous water temperature.
   1. Pump Construction: Bronze fitted.
      a. Casing: Radially split, cast iron, with wear rings and threaded companion-flange connections for pumps with NPS 2 pipe connections with flanged connections for pumps with NPS 2-1/2 pipe connections. Submission shall include the pump manufacturer's base attachment for mounting pump on concrete base.
      b. Impeller: 316 Stainless steel; statically and dynamically balanced, closed, and keyed to shaft.
      c. Shaft and Shaft Sleeve: Stainless-steel shaft, with copper-alloy shaft sleeve.
      d. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
      e. Bearings: Oil-lubricated; bronze-journal or ball type.
   2. Shaft Coupling: Rigid type if pump is provided with coupling.
   3. Motor: Single speed, with grease-lubricated ball bearings; and directly mounted to pump casing. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

2.6 VARIABLE SPEED BOOSTER PUMPS
A. Description: Factory-assembled and -tested, packaged booster pump with multiple pumps, piping, valves, sensors, controls on skids or base, and painted with machinery enamel at factory. Field assembled units are not acceptable.
B. System Working-Pressure Rating: 150 psig minimum.
C. Pump Arrangement: Multiple pumps, each of equal-size.
D. Manufacturers:
   1. Grundfos.
   2. Bell & Gossett Domestic Pump; ITT Industries
   3. Delta P Carver
   4. Metropolitan.
   5. Synacroflo, Inc.
E. The control system shall include, as a minimum, pump and motor assemblies, the programmable logic pump controller, adjustable frequency drive(s), suction and discharge piping, and additional equipment as specified or as required in order to properly execute the sequence of operation. Furnish field installed remote sensor/transmitters as indicated on the plans.

F. System shall require only suction and discharge connections and a single point power connection. Field connection of remote sensor/transmitters and connection to Building Automation System shall be by controls contractor.

G. All components shall be mounted on a structural steel base suitable for grouting.

H. Provide pumps as indicated on the pump schedule. Pumps and motors shall be furnished as specified in respective sections of this document.

I. The discharge of each pump shall be fitted with a control valve. Each pump and discharge valve assembly shall be equipped with isolation valves so that the pump can be serviced while system is still filled.

J. Pumps shall be closed-coupled, end suction type. Sizes ad capacities shall be as shown on the plans.

K. Pressure gauges shall be installed on the suction and discharge headers and shall be 4-1/2 inch diameter minimum.

L. Suction and discharge headers shall have flanges for isolation valves furnished and installed by plumbing contractor.

2.7 COMPONENTS

A. Pump Logic Controller:

1. The pump’s programmable logic controller assembly shall be listed by and bear the label of Underwriter's Laboratory, Inc. (UL); the controller shall meet Part 15 of FCC regulations pertaining to Class A computing devices. The controller shall be specifically designed for variable speed pressure boosting applications.

2. The controller shall function to a proven program that safeguards against damaging hydraulic conditions, including:

   a. Motor overload.
   b. Pump flow surges.
   c. System over pressure.
   d. Hunting.

3. The controller shall be capable of receiving up to four remote pressure signals. It will then select the analog signal that has deviated the greatest amount from its set point. This selected signal will be used as the command feedback input for a hydraulic stabilization function to minimize hunting. Each input signal shall be capable of maintaining a different set point value. Controller shall be capable of controlling up to two pumps in parallel.

4. The controller shall have an additional analog input for a flow sensor. This input shall serve as the criteria for the end of curve protection algorithm.

5. The hydraulic stabilization program shall utilize a proportional-integral-derivative control function. The proportional, integral, and derivative values shall be user adjustable over an infinite range.

6. Controller shall be capable of performing the following pressure booster functions:
a. Low suction pressure cutout to protect the pumps against operating when with insufficient suction pressure.

b. High system pressure cutout to protect the piping system against high-pressure conditions.

7. The following communication features shall be provided to the BAS:

   a. Failure of any system component (general alarm).
   b. Process variable.
   c. VFD speed.
   d. System on/off status.

8. The controller enclosure shall be NEMA 1.

9. No hand/manual/bypass selector will be allowed.

B. Variable Frequency Drive:

   1. The adjustable frequency drive(s) shall be pulse width modulation (PWM) type, microprocessor controlled design.
   2. The VFD, including all factory-installed options, shall have UL approval.
   3. Enclosure shall be NEMA 1 ventilated for installation as a wall mounted or freestanding unit, depending on the amp rating. Drive shall be equipped with an input disconnect switch and fuses to protect against ground faults. A hand-off-automatic switch and speed potentiometer shall be mounted on the front of the enclosure.
   4. VFD shall utilize a full wave rectifier to convert three phase AC to a fixed DC voltage. Power factor shall remain above 0.98 regardless of speed or load. VFDs employing power factor correction capacitors shall not be acceptable.
   5. Insulated gate bipolar transistors shall be used in the inverter section to convert the fixed DC voltage to a three phase, adjustable frequency, AC output. A DC line reactor shall be provided to minimize harmonic and current distortion of the input power line.
   6. Speed reference signal shall be customer selectable for 0-10 VDC.
   7. The VFD shall be suitable for elevations to 3300 feet above sea level without derating. Maximum operating ambient temperature shall not be less than 104 degrees F. VFD shall be suitable for operation in environments up to 95% non-condensing humidity.
   8. The VFD shall be capable of displaying the following information:

      a. Output frequency.
      b. Output voltage.
      c. Motor current.
      d. Kilowatts per hour.
      e. Fault identification with text.
      f. Percent torque.
      g. Percent power.
      h. RPM,

C. Automatic VFD Bypass:

   1. Variable speed pumping system shall be equipped with an automatic bypass.
   2. Bypass shall consist of a main power disconnect with ground fault protection, a pair of interlocked contactors and a motor overlay relay. All are to be mounted in a NEMA 1 enclosure.
   3. Automatic bypass shall operate as described in the sequence of operation.

D. Sensor/Transmitters:
1. Provide field mounted single point pressure sensor transmitter(s) as indicated on the plans. Unit shall transmit an isolated 4-20 ma DC signal indicative of process variable to the pump logic controller via standard two wire 24 VDC system. Unit shall have stainless steel wetted parts with one 0.25" male NPT process connection. It shall be protected against radio frequency interference and shall have a watertight, NEMA 4 electrical enclosure with a 0.5" NPT conduit connection. Accuracy shall be within 0.25% of full span.

2.8 CONTROLS FOR HOT WATER CIRCULATOR

A. Thermostats: Electric; adjustable for control of hot-water circulation pump.
   1. Manufacturers:
      a. Honeywell International, Inc.
      b. Square D.
   2. Type: Water-immersion sensor, for installation in hot-water circulation piping.
   3. Range: 50 to 125°F.
   4. Operation of Pump: On or off.
   5. Transformer: Provide if required.
   6. Power Requirement: 24 V, ac or 120 V, ac.
   7. Settings: Start pump at 105 deg F and stop pump at 120 deg F.
   8. Provide additional temperature contact to be connected to the Building Automation System (BAS).

B. Timers: Control of hot-water circulation pump(s) shall be by the Building automation system
   1. Type: Programmable, seven-day clock with manual override on-off switch.
   2. Local disconnect Operation of Pump: On or off.
   3. Transformer: Provide if required.
   4. Power Requirement: 24 V, ac or 120 V, ac.
   5. Programmable Sequence of Operation: Up to two on-off cycles each day for seven days.

2.9 FLEXIBLE CONNECTORS

A. Manufacturers:
   1. Anamet, Inc.
   2. Flex-Hose Co., Inc.
   3. Flexicraft Industries.
   4. Flex-Pression, Ltd.
   5. Flex-Weld, Inc.
   6. Hyspan Precision Products, Inc.
   8. Metraflex, Inc.
   9. Proco Products, Inc.
   10. Tozen America Corporation.
   11. Unaflex Inc.

B. Description: Corrugated, bronze inner tubing covered with bronze wire braid. Include copper-tube ends or bronze-flanged ends, braze-welded to tubing. Include 125-psig minimum working-pressure rating and ends matching pump connections.
2.10 BUILDING-AUTOMATION-SYSTEM INTERFACE

A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:
   1. On-off status of each pump.
   2. Alarm status of each pump.
   3. Discharge Pressure, (Booster Pumps)
   4. Suction Pressure, (Booster Pumps)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

3.2 CONCRETE BASES

A. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Division 22 Section "Basic Division 22 Requirements."
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.3 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Install [in-line, sealless] [close-coupled, horizontally mounted, in-line] centrifugal pumps with motor and pump shafts horizontal.

E. Install continuous-thread hanger rods and elastomeric hangers of sufficient size to support pump weight. Fabricate brackets or supports as required. Hanger and support materials are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

F. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and elastomeric hangers of sufficient size to support pump weight. Hanger and support materials are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

G. Install vertical in-line pumps on concrete bases. Install pumps with motor and pump shafts vertical.

DOMESTIC WATER PUMPS
3.4 CONTROL INSTALLATION
   A. Install immersion-type thermostats in hot-water return piping.
   B. Install timers on wall adjacent to pump if not integral to pump.

3.5 CONNECTIONS
   A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate
   general arrangement of piping, fittings, and specialties.
   B. Install piping adjacent to pumps to allow service and maintenance.
   C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or
   greater than size of pump nozzles. Refer to Division 22 Section "Domestic Water Piping."
      1. Install flexible connectors adjacent to pumps in suction and discharge piping of the
      following pumps:
         b. Close-coupled, vertically mounted, in-line centrifugal pumps.
      2. Install shutoff valve and strainer on suction side of pumps, and check valve and throttling
         valve on discharge side of pumps. Install valves same size as connected piping. Refer
         to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves
         for domestic water piping and Division 22 Section "Domestic Water Pump Specialties" for
         strainers.
      3. Install pressure gages at suction and discharge of pumps. Install at integral pressure-
         gage tappings where provided or install pressure-gage connectors in suction and
         discharge piping around pumps. Refer to Division 22 Section "Meters and Gages for
         Plumbing Piping" for pressure gages and gage connectors.
      4. Provide unions in suction and discharge piping of the pumps.
   D. Ground equipment according to Division 26 Section "Grounding and Bonding."
   E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and
      Cables."
   F. Connect thermostats and timers to pumps that they control.
   G. Interlock pump with water heater burner and time delay relay.

3.6 STARTUP SERVICE
   A. Engage a factory-authorized service representative to perform startup service.
      1. Complete installation and startup checklists according to manufacturer’s written
         instructions.
      2. Check piping connections for tightness.
      3. Clean strainers on suction piping.
      4. Set thermostats and timers for automatic starting and stopping operation of pumps.
      5. Perform the following startup checks for each pump before starting:
         a. Verify bearing lubrication.
         b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is
            free to rotate with pump hot and cold. If pump is bound or drags, do not operate
            until cause of trouble is determined and corrected.
         c. Verify that pump is rotating in the correct direction.
6. Prime pump by opening suction valves and closing drains and prepare pump for operation.
7. Start motor.
8. Open discharge valve slowly.
9. Adjust temperature settings on thermostats.
10. Adjust timer settings.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 221123
SECTION 221316 – SANITARY, WASTE, VENT AND, STORM PIPING

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following for soil, waste, and vent piping inside the building:
   1. Pipe, tube, and fittings.
   2. Special pipe fittings.
B. Related Sections include the following:
   1. Division 22 Section "Sanitary Sewerage Pumps."
   2. Division 22 Section "Chemical Waste-Systems for Healthcare Facilities".
   3. Division 22 Section "Sump Pumps."
   4. Division 22 Section “Sanitary, Waste and Storm Drainage Specialties”
   5. Division 07 Section “Penetration Firestopping”

1.2 DEFINITIONS
B. EPDM: Ethylene-propylene-diene terpolymer rubber.
C. LLDPE: Linear, low-density polyethylene plastic.
D. NBR: Acrylonitrile-butadiene rubber.
E. PVC: Polyvinyl chloride plastic.
F. CISPI: Cast iron Soil Pipe Institute

1.3 PERFORMANCE REQUIREMENTS
A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
   2. Storm Water Piping: 10-feet head of water.

1.4 SUBMITTALS
A. General: Submit the following in accordance with Division 22 Section "Basic Division 22 Requirements."

1.5 ACTION SUBMITTALS
A. Product Data: For pipe, tube, fittings, and couplings.
B. Shop Drawings:
   1. Sustainability/Sustainable Credit Applicability:
      a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping; "NSF-drain" for plastic drain piping; "NSF-tubular" for plastic continuous waste piping; and "NSF-sewer" for plastic sewer piping.

C. Comply with CISPI Standard 301 Specification Data for Cast iron Soil Pipe and Fittings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications“ Article for applications of pipe, tube, fitting, and joining materials.

2.3 CAST IRON PIPE AND FITTINGS

A. Service weight Cast Iron Soil Piping and Fittings: ASTM A74; ANSI A-112.5.1 and ASTM C564

1. Hub and Spigot Cast Iron piping and fittings joined with neoprene gasket, Drainage patterns as identified in ASTM A74.

2. Hubless Cast Iron piping and fittings, neoprene sleeve and heavy duty, minimum 4-band stainless steel clamp. Drainage patterns in accordance with CISPI 301

2.4 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

B. Solvent Cement and Adhesive Primer:

1. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.5 FOUNDATION DRAINTILE PIPING AND FITTINGS

A. Pipes and Fittings


B. Filter Fabric:
   1. Woven geotextile filter fabric, in 1 or more layers, for minimum total weight of 3 oz./sq. yd. (0.10 kg/sq. m). Include fabric covering for entire length of tile installation.

C. Special Pipe Couplings:
   1. Description: Rubber or elastomeric sleeve and band assembly fabricated to match outside diameters of pipes to be joined. Include the following specific sleeve materials, where available:
      b. Dissimilar Pipes: Compatible with pipe materials being joined.
      c. Bands: Stainless steel, at least 1 at each pipe insert.

D. Soil Materials:
   1. Impervious Fill: Clayey gravel and sand mixture capable of compacting to dense state.
   2. Drainage Fill: Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel, ASTM D 448, coarse aggregate, Size No. 57, with 100 percent passing 1-1/2-inch (37.5-mm) sieve and not more than 5 percent passing No. 8 (2.36-mm) sieve.
   3. Filtering Material: Evenly graded mixture of natural or crushed gravel or crushed stone and natural sand, with 100 percent passing 1-1/2-inch (37.5-mm) sieve and 0 to 5 percent passing No. 50 (0.3-mm) sieve.

2.6 SPECIAL PIPE FITTINGS
A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.
   1. Manufacturers:
      b. Fernco, Inc.
      c. Logan Clay Products Company (The).
      d. Mission Rubber Co.
      e. NDS, Inc.
   2. Sleeve Materials:
      a. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
      b. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

B. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
   1. Manufacturers:
      b. Mission Rubber Co.

C. Rigid, Unshielded, Nonpressure Pipe Couplings: ASTM C 1461, sleeve-type reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.
1. Manufacturers:
   a. ANACO.

D. Pressure Pipe Couplings: AWWA C219 metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
   1. Manufacturers:
      b. Dresser, Inc.; DMD Div.
      c. EBAA Iron Sales, Inc.
      d. Ford Meter Box Company, Inc. (The); Pipe Products Div.
      e. JCM Industries, Inc.
      f. Romac Industries, Inc.
      g. Smith-Blair, Inc.
      h. Viking Johnson.

2. Center-Sleeve Material: Manufacturer's standard.
3. Gasket Material: Natural or synthetic rubber.
4. Metal Component Finish: Corrosion-resistant coating or material.

E. Flexible Ball Joints: Ductile-iron fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include gasketed ball-joint section and ductile-iron gland, rubber gasket, and steel bolts.
   1. Manufacturers:
      a. EBAA Iron Sales, Inc.

F. Expansion Joints: Two or three-piece, ductile-iron assembly consisting of telescoping sleeve(s) with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
   1. Manufacturers:
      a. EBAA Iron Sales, Inc.
      b. Romac Industries, Inc.
      c. Star Pipe Products; Star Fittings Div.

PART 3 - EXECUTION

3.1 EXCAVATION
   A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS
   A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.
   B. Aboveground, soil and waste piping shall be the following:
      1. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
      2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
C. Aboveground, vent piping shall be the following:
   1. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

D. Underground, soil, waste, and vent piping shall be the following:
   1. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

E. Aboveground or below sanitary, waste, and storm water, force mains shall be the following:
   1. Solid wall schedule 80 PVC piping conforming to ASTM d 1785.
   2. Schedule 80 PVC fittings conforming to ASTM D 2467.

3.3 PIPING INSTALLATION

A. Basic piping installation requirements are specified in Division 22 Section "Basic Division 22 Requirements."

B. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers. Provide cleanouts at changes of direction, horizontally and vertically. Locations shall be a minimum of end of runs, and at 50 foot intervals for 4-inch and smaller piping and 100 foot intervals for piping larger than 4-inch.

C. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.

D. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

E. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.

F. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drainpipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

G. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

H. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:
   1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 2 and smaller; 1 percent downward in direction of flow for piping NPS 3 inch and larger.
2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow NPS 2 and smaller; 1 percent downward in direction of flow for piping NPS 3 inch and larger.
3. Vent Piping: Sloped down toward vertical fixture vent or toward vent stack.

I. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.
J. Install underground PVC soil and waste drainage piping according to ASTM D 2321.
K. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.4 JOINT CONSTRUCTION
A. Basic piping joint construction requirements are specified in Division 22 Section "Basic Division 22 Requirements."
B. PVC Non-pressure Piping Joints: Join piping according to ASTM D 2665.

3.5 VALVE INSTALLATION
A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
B. Shut-off Valves: Install shut-off valve on each sewage pump discharge.
   1. Install full-port ball valve for piping NPS 2 and smaller.
   2. Install butterfly valves for piping NPS 2-1/2 and larger.
C. Check Valves: Install swing check valve, between pump and shut-off valve, on each sewage pump discharge.
D. Backwater Valves: Install backwater valves in piping subject to sewage backflow.
   1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
   2. Install backwater valves in accessible locations.
   3. Backwater valve are specified in Division 22 Section "Sanitary Waste Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION
A. See Section 220529 “Hangers and Supports.”

3.7 CONNECTIONS
A. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
C. Connect drainage and vent piping to the following:
   1. Plumbing Fixtures: Connect drainage piping in sizes indicated, never smaller than required by plumbing code.
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, never smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, never smaller than required by plumbing code.
4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

E. Connect storm drainage piping to roof drains and storm drainage specialties.

F. Connect force-main piping to the following:
   1. Sanitary Sewer: To exterior force main or sanitary manhole.
   2. Sewage Pumps: To sewage pump discharge.
   3. Storm Sewer: To exterior force main or storm manhole.
   4. Sump Pumps: To sump pump discharge.

3.8 FOUNDATION DRAINAGE SYSTEM APPLICATIONS

A. Systems with 4-Inch Piping: As follows:
   1. Perforated, polyethylene (PE) pipe and fittings, couplings, and coupled joints.
   2. Perforated, polyvinyl chloride (PVC) sewer pipe and fittings for loose, bell-and-spigot joints.

B. Systems with 6-Inch and Larger Piping: As follows:
   1. Perforated, polyvinyl chloride (PVC) sewer pipe and fittings for loose, bell-and-spigot joints.

3.9 FOUNDATION PIPING APPLICATIONS

A. Drawing plans and details indicate general location and arrangement of foundation drainage piping system.

B. Contractor shall carefully coordinate installation procedure with general contractor and other contractors.

C. Contractor shall obtain the latest soil report and coordinate installation procedure with soil consultant’s recommendations.

D. Installation procedure as follows:
   1. Excavation.
   4. Placement of piping.
   5. Placement of filtering fill/gravel.
   7. Integration of foundation wall drainage mats to foundation drainage system as instructed by manufacturers.
   8. Complete backfill procedure.

E. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing, solidly in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer’s written instructions and other requirements indicated.
1. Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of 36 inches, except where otherwise indicated.
2. Apply and compact impervious fill material to raise all low areas and / or where unsatisfactory bearing soil may occur.

F. Use increases, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.
G. Extend piping and connect to building storm drains, of sizes and in location indicated. Terminate piping as indicated.
H. Provide cleanouts as indicated on drawings and at all offsets greater than 45° and as required by code.

3.10 DRAINTILE CLEANOUT INSTALLATION
A. Install cleanouts and riser extensions from foundation drainage piping to cleanouts at grade and extensions through foundation walls to cleanouts at basement walls. Use PVC fittings for foundation drainage piping branch fittings and extensions to cleanouts. Install fittings so cleanouts open in direction of flow in piping.
B. Set cleanout frames and covers in earth in a cast-in-place concrete anchor, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding earth grade, slope concrete at 1/8-inch per foot to edges. Set cleanout frames and covers in concrete paving with tops flush with paving surface.
C. Set cleanout frames in foundation walls prior to concrete pour. Set frame flush with interior wall surface. Provide mechanical seal watertight penetration seal between frame and cleanout extension ferrule.
D. Set cleanout frames and covers in foundation walls with covers flush with finished wall surface.

3.11 DRAINTILE SLEEVE INSTALLATION
A. Install sleeves in locations where piping penetrates foundation walls. Set sleeves prior to concrete pour.

3.12 DRAINTILE SOIL MATERIAL INSTALLATION
A. Impervious Fill at Footings: Place impervious fill material on subgrade adjacent to bottom of footing after concrete footings have been cured and forms removed. Place and compact impervious fill to dimensions indicated but not less than 6 inches deep and 12 inches wide.
B. Filtering Material: Place supporting layer of filtering material over compacted subgrade where drainage pipes are to be laid to depth indicated or, if not indicated, to compacted depth of not less than 6 inches.
C. Drainage Fill: Place fill over drain piping after satisfactory testing and covering with filtering material. Cover piping to width of at least 6 inches on each side and above top of pipe to within 12 inches of finish grade. Place fill material in layers not exceeding 3 inches in loose depth, and compact each layer placed.
D. Fill to Grade: Place impervious fill material over compacted drainage fill. Place material in loose-depth layers not exceeding 6 inches. Thoroughly compact each layer. Fill to finish elevations and slope away from building.
3.13 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg (250 Pa). Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow standing for four (4) hours. Leaks and loss in test pressure constitute defects that must be repaired.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.
3.14 CLEANING
   A. Clean interior of piping. Remove dirt and debris as work progresses.
   B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
   C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.15 PROTECTION
   A. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

END OF SECTION 221316
SECTION 221329 – STORM, CLEARWATER AND SANITARY SEWERAGE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following storm, clearwater and sanitary sewage pumps and accessories for sanitary drainage piping systems in buildings:
   1. Wet-pit-mounted, vertical sump pumps.
   2. Submersible sump pumps.
   3. Wet-pit-mounted, vertical sewage pumps.
   4. Submersible sewage pumps.
   5. Sewage pump basins and pits.
   6. Packaged, submersible sewage pump units.
   7. Packaged, wastewater pump units.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 22 Section "Basic Division 22 Requirements."

1.3 ACTION SUBMITTALS

A. Product Data: For each type and size of sewage pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.

B. Shop Drawings:
   1. Wiring: Diagram power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each sewage pump to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings shall indicate size, profiles, and dimensional requirements of sewage pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. For each installed pump, provide a risk assessment in conjunction with the plant operations group complete with interface to the building’s automation system. In addition, the limitations and capabilities of each pump shall be identified and documented.

D. Hydraulic Institute Compliance: Design manufacture, and install plumbing pumps in accordance with "Hydraulic Institute Standards."

E. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Motor operated water pumps shall be listed and labeled by a NRTL. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.
F. UL Compliance: Plumbing pumps shall be listed and labeled by UL and comply with UL Standard 778 "Motor Operated Water Pumps".

G. NEMA compliance: Electric motors and components shall be listed and labeled NEMA.

H. SSPMA Compliance: Test and rate sump and sewage pumps in accordance with the Sump and Sewage Pump Manufacturers Association (SSPMA) Standards.

I. Single-Source Responsibility: Obtain plumbing pumps of the same type from a single manufacturer.

J. No simplex pumping system allowed except for elevator sump systems.

K. Unless otherwise indicated, all pump discharge piping shall be in accordance with the piping schedule.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

1.7 COORDINATION

A. Coordinate size and location of concrete bases and pits. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: Per the manufacturer listed.

B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

C. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 WET-PIT-MOUNTED, VERTICAL SUMP PUMPS

A. Manufacturers:

1. Armstrong Pumps Inc.
2. Aurora Pump; Pentair Pump Group (The).
3. Chicago Pump Company; a division of Yeomans Chicago Corporation.
4. Federal Pump Corp.
5. Ingersoll-Dresser Pumps.
7. Weil Pump Company, Inc.

STORM, CLEARWATER AND SANITARY SEWERAGE PUMPS

B. Description: Factory-assembled and -tested, single-stage, centrifugal, end-suction sump pumps complying with UL 778. Vertical, separately coupled, suspended pumps complying with HI 1.1-1.2 and HI 1.3 for wet-pit-volute sump pumps.
1. Pump Arrangement: Multiple.
2. Casing: Cast iron, with screened inlet and threaded connection for NPS 2 (DN 50) and smaller and flanged connection for NPS 2-1/2 (DN 65) and larger discharge piping.
3. Impeller: 316 Stainless Steel; statically and dynamically balanced nonclogging design; overhung, single suction, keyed and secured to shaft.
4. Pump Shaft and Sleeve Bearings: Stainless-steel shaft with bronze sleeve bearings. Include oil-lubricated, intermediate sleeve bearings at 48-inch maximum intervals if basin depth is more than 48 inches and grease-lubricated, ball-type thrust bearings.
5. Pump and Motor Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.

C. Pump Discharge Piping: Manufacturer's standard galvanized-steel or bronze pipe.

D. Basin or Pit Cover: Cast iron or steel with bituminous coating and strong enough to support pumps, motors, and controls. See Part 2 "Sump Pump Basin and Pits" Article for requirements.

E. Cover Shaft Seal: Stuffing box, with graphite-impregnated braided-yarn rings and bronze packing gland.

F. Motor: Single speed; grease-lubricated ball bearings. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment" with built-in thermal-overload protection appropriate for motor size and duty.
1. Mounting on vertical, cast-iron pedestal.

G. Controls: NEMA 250, Type 1, enclosure, pedestal-mounted float switches; with floats, float rods, and rod buttons. Include automatic alternator to alternate operation of pump units on successive cycles and to operate multiple units if one pump cannot handle load.
1. Float Guide: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches.
2. High-Water Alarm and sump level control switches: Cover-mounted, micro pressure-switch alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

2.3 SUBMERSIBLE SUMP PUMPS

A. Manufacturers:
1. ABS Pumps, Inc.
2. Barnes; Crane Pumps & Systems.
3. Bell & Gossett Domestic Pump; ITT Industries.
4. Federal Pump Corp.
5. Gorman-Rupp Company (The).
7. Grundfos Pumps Corp.
8. Liberty Pumps.
9. Little Giant Pump Co.
11. Metropolitan Industries, Inc.
12. Myers, F. E.; Pentair Pump Group (The).
13. Stancor, Inc.
15. Weinman Div.; Crane Pumps & Systems.

B. Description: Factory-assembled and -tested, [simplex] [duplex] <insert other>, single-stage, centrifugal, end-suction, submersible, direct-connected sump pumps complying with UL 778 and HI 1.1-1.2 and HI 1.3 for submersible sump pumps.

C. Casing: Cast iron; with cast-iron inlet strainer, legs that elevate pump to permit flow into impeller, and vertical discharge with companion flange for piping connection.

D. Impeller: stainless steel; statically and dynamically balanced, semi-open nonclogging design, overhung, single suction, keyed and secured to shaft.

E. Casing: Stainless steel; with stainless-steel inlet strainer, legs that elevate pump to permit flow into impeller, and vertical discharge with companion flange suitable for piping connection.

F. Impeller: Stainless steel.

G. Pump and Motor Shaft: Stainless steel with factory-sealed, grease-lubricated ball bearings and double-mechanical seals.

H. Motor: Hermetically sealed, capacitor-start type, with built-in overload protection; three-conductor waterproof power cable of length required, and with grounding plug and cable-sealing assembly for connection at pump. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

1. Moisture-Sensing Probe: Internal moisture sensor with moisture alarm.

I. Pump Discharge Piping: Factory or field fabricated, ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with rolled groove fittings and mechanical clamps.

J. Basin or Pit Cover: Cast iron or steel with bituminous coating and strong enough to support controls and the expected traffic. All openings, (Piping, controls and access), shall be mechanically sealed and the cover shall be gas-tight.

K. Controls: NEMA 250, Type 1 enclosure, pedestal-mounted float switch; with float, float rod, and rod buttons. Include automatic alternator to alternate operation of pump units on successive cycles and to operate multiple units if one pump cannot handle load.

2.4 WET-PIT-MOUNTED, VERTICAL SEWAGE PUMPS

A. Manufacturers:

1. Armstrong Pumps Inc.
2. Aurora Pump; Pentair Pump Group (The).
3. Chicago Pump Company; a division of Yeomans Chicago Corporation.
4. Federal Pump Corp.
5. Paco Pumps, Inc.
8. Yeomans Chicago Corporation.

B. Description: Factory-assembled and -tested, single-stage, centrifugal, end-suction sewage pumps complying with UL 778. Vertical, separately coupled, suspended pumps complying with HI 1.1-1.2 and HI 1.3 for wet-pit-volute sewage pumps and with reverse-flow assembly.
2. Casing: Cast iron, with open inlet and threaded connection for NPS 2 and smaller and flanged connection for NPS 2-1/2 and larger discharge piping.
3. Impeller: Stainless steel, statically and dynamically balanced, open or semi-open, nonclogging design for solids handling; overhung, single suction, and keyed and secured to shaft.
4. Pump Shaft and Sleeve Bearings: Stainless steel shaft with bronze sleeve bearings. Include oil-lubricated, intermediate sleeve bearings at 48-inch maximum intervals if basin depth is more than 48 inches, and grease-lubricated, ball-type thrust bearings.
5. Pump and Motor Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.

C. Pump Discharge Piping: Manufacturer's standard galvanized-steel or bronze pipe.
D. Basin or Pit Cover: Cast iron or coated steel and strong enough to support pumps, motors, and controls. See Part 2 "Sewage Pump [Basins] [Pits]" Article for requirements.
E. Cover Shaft Seal: Stuffing box, with graphite-impregnated braided-yarn rings and bronze packing gland.
F. Motor: Single-speed; grease-lubricated ball bearings. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."
G. Controls: NEMA 250, Type 1 enclosure, pedestal-mounted float switches; with floats, float rods, and rod buttons. Include automatic alternator to alternate operation of pump units on successive cycles and to operate multiple units if one pump cannot handle load.
1. Float Guide: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches.
2. High-Water Alarm and control floats: Cover-mounted, pressure diaphragm switches, alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

2.5 SUBMERSIBLE SEWAGE PUMPS
A. Submersible, Fixed-Position Sewage Pumps: Factory-assembled and -tested, duplex single-stage, centrifugal, end-suction, submersible, direct-connected sewage pumps complying with UL 778 and with HI 1.1-1.2 and HI 1.3 for submersible sewage pumps.
1. Manufacturers:
   a. Barnes; Crane Pumps & Systems.
   b. Bell & Gossett Domestic Pump; ITT Industries.
   c. EBARA International Corporation; Standard Pump Division.
   d. Fairbanks Morse; Pentair Pump Group (The).
   e. Flygt; ITT Industries.
   f. Goulds Pumps; ITT Industries.
   g. Hydromatic Pumps; Pentair Pump Group (The).
   h. KSB Inc.
   i. Liberty Pumps.
   j. Little Giant Pump Co.
   k. Metropolitan Industries, Inc.
   l. Myers, F. E.; Pentair Pump Group (The).
   m. Stancor, Inc.
   n. Sta-Rite Industries, Inc.
   o. Sterling Peerless; Sterling Fluid Systems Group.
2. Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, and vertical discharge with companion flange for piping connection.

3. Impeller: Stainless Steel impeller; statically and dynamically balanced, open or semi-open, non-clog design and capable of handling solids; overhung, single suction, and keyed and secured to shaft.


5. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump. Comply with Division 22 Section "Common Motor Requirements for Plumbing Equipment."

a. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.

b. Motor Housing Fluid: Air

B. Submersible, Quick-Disconnect Sewage Pumps: Factory-assembled and -tested, duplex single-stage, centrifugal, end-suction, submersible, direct-connected sewage pumps complying with UL 778 and with HI 1.1-1.2 and HI 1.3 for submersible sewage pumps and with SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook" for guide-rail supports. Include reverse-flow assembly.

1. Manufacturers:

   a. Chicago Pump Company; a division of Yeomans Chicago Corporation.
   b. Deming Pumps; Crane Pumps & Systems.
   c. Fairbanks Morse; Pentair Pump Group (The).
   d. Federal Pump Corp.
   e. Flygt; ITT Industries.
   f. Gorman-Rupp Company (The).
   g. Goulds Pumps; ITT Industries.
   h. Hydromatic Pumps; Pentair Pump Group (The).
   i. Metropolitan Industries, Inc.
   j. Myers, F. E.; Pentair Pump Group (The).
   k. Stancor, Inc.
   l. Swaby Manufacturing Co.
   m. Weil Pump Company, Inc.
   n. Weinman Div.; Crane Pumps & Systems.
   o. Yeomans Chicago Corporation.

2. Casing: Cast iron, with open inlet, legs (or guide-rail supports) that elevate pump to permit flow into impeller, and vertical discharge with companion flange for piping connection.

3. Impeller: Stainless Steel impeller; statically and dynamically balanced, open or semi-open, non-clog design and capable of handling solids; overhung, single suction, and keyed and secured to shaft.

5. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump. Comply with Division 22 Section "Common Motor Requirements for Plumbing Equipment."
   a. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.
   b. Motor Housing Fluid: Air

6. Guide-Rail Supports: Include the following for each sewage pump:
   a. Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
   b. Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
   c. Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
   d. Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
   e. Stationary Elbow: Fixed discharge-elbow fitting with flange that mate to movable-elbow flange and support attached to baseplate.
   f. Lifting Cable: Stainless steel; attached to pump and cover at manhole.

C. Submersible, Quick-Disconnect Grinder Pumps: Factory-assembled and -tested, duplex single-stage, centrifugal, end-suction, submersible, direct-connected grinder pumps complying with UL 778 and with HI 1.1-1.2 and HI 1.3 for submersible sewage pumps and with SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook" for guide-rail supports.

1. Manufacturers:
   a. Alyan Pump Company.
   b. Flygt; ITT Industries.
   c. Hydromatic Pumps; Pentair Pump Group (The).
   d. Liberty Pumps.
   e. Myers, F. E.; Pentair Pump Group (The).
   f. Stancor, Inc.
   g. Weil Pump Company, Inc.
   h. Zoeller Company.

2. Casing: Cast iron, with open inlet, legs (or guide-rail supports) that elevate pump to permit flow into impeller, and vertical discharge with companion flange for piping connection.

3. Impeller: Stainless steel; statically and dynamically balanced, with stainless-steel cutter, grinder, or slicer assembly and capable of handling solids; overhung, single suction, and keyed and secured to shaft.

4. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings and double mechanical seals.

5. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump. Comply with Division 22 Section "Common Motor Requirements for Plumbing Equipment."
   a. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.
   b. Motor Housing Fluid: Air

6. Guide-Rail Supports: Include the following for each sewage pump:
a. **Guide Rails:** Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
b. **Baseplate:** Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
c. **Pump Yoke:** Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
d. **Movable Elbow:** Pump discharge-elbow fitting with flange, seal, and positioning device.
e. **Stationary Elbow:** Fixed discharge-elbow fitting with flange that mate to movable-elbow flange and support attached to baseplate.
f. **Lifting Cable:** Stainless steel; attached to pump and cover at manhole.

D. **Pump Discharge Piping:** Factory or field fabricated, Schedule 80 PVC or as otherwise identified.

E. **Basin or Pit Cover:** Cast iron or coated steel and suitable to support controls. See Part 2 Basin and Pit Covers.

F. **Controls:** NEMA 250, Type 1 enclosure, pedestal-mounted float switch; with floats, float rods, and rod buttons. Include automatic alternator to alternate operation of pump units on successive cycles and to operate multiple units if one pump cannot handle load.
   1. **Float Guide:** Pipe or other restraint for floats and rods in basins of depth greater than 60 inches.
   2. **High-Water Alarm:** Rod-mounted, NEMA 250, Type 6 enclosure with mechanical switch alarm matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

2.6 **PUMP BASINS**

A. **Description:** Factory fabricated basin with sump, pipe connections, and cover.

B. **Sump:** Fabricate watertight, with sidewall openings for pipe connections.
   1. **Material:** Fiberglass
   2. **Reinforcement:** Mounting plates for pumps, fittings, guide-rail supports, and accessories.
   3. **Anchor Flange:** Same material as or compatible with sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab. In addition provide anti-buoyancy anchoring as required for "empty" pit conditions.

C. **Cover:** Fabricate with openings having gastight gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
   1. **Material:** Galvanized Plate Steel
   2. **Reinforcement:** Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

2.7 **PUMP PITS**

A. **Description:** Concrete pit with sump, pipe connections, curb frame, and cover.

B. **Sump:** Construct of sealed, cast-in-place, reinforced concrete with sidewall openings for pipe connections. Cast-in-place concrete, formwork, and reinforcement are specified in Division 03 "Cast-In-Place Concrete"
1. Pipe Connections: Sleeved openings large enough for mechanical sleeve seals for drainage piping. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Basic Division 22 Requirements" and drainage piping is specified in Division 22 Section "Sanitary Waste and Vent Piping."

C. Frame and Cover:
   1. Frame Material: Galvanized steel or steel with bituminous coating.
      a. Pattern: Z-cross-section shape with raised outer rim of height matching cover, for recessed mounting with installed cover flush with top of floor slab.
   2. Cover: Fabricate with openings having gas-tight gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
      a. Material: Galvanized Plate Steel
      b. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

2.8 FLEXIBLE CONNECTORS

A. Manufacturers:
   1. Anamet, Inc.
   2. Flex-Hose Co., Inc.
   3. Flexicraft Industries.
   4. Flex-Pression, Ltd.
   5. Flex-Weld, Inc.
   6. Hyspan Precision Products, Inc.
   8. Metraflex, Inc.
   9. Proco Products, Inc.
  10. Tozen America Corporation.
  11. Unaflex Inc.

B. Description: 125-psig > minimum working-pressure rating and ends matching pump connections:
   1. Bronze Flexible Connectors: Corrugated, bronze inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flange ends, braze-welded to tubing.
   2. Stainless-Steel Flexible Connectors: Corrugated, stainless-steel inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to tubing.

2.9 BUILDING AUTOMATION SYSTEM INTERFACE add risk assessment, and evaluate each system with Plant ops.

A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:
   1. On-off status of each pump.
   2. Alarm status.
   3. High Water Alarm.
   4. Pump run indicators.
   5. Pump Run Time.
   6. Water level.
PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine roughing-in for plumbing piping to verify actual locations of sanitary drainage and vent piping connections before sewage pump installation.

3.2 CONCRETE
   A. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Division 22 Section "Basic Division 22 Requirements."
      1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
      2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
      3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
      4. Install anchor bolts to elevations required for proper attachment to supported equipment.
   B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.3 INSTALLATION
   A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."
   B. Install sewage pumps according to applicable requirements in HI 1.4.
   C. Install pumps and arrange to provide access for maintenance including removal of motors, impellers, couplings, and accessories.
   D. Suspend wet-pit-mounted, vertical sewage pumps from [basin] [basin and pit] [pit] covers. Make direct connections to sanitary drainage piping.
   E. Set submersible sewage pumps on sump pit floors. Make direct connections to sanitary drainage piping.
      1. Anchor guide-rail supports to sump pit bottoms and sidewalls or covers. Install pumps so pump and discharge pipe disconnect flanges make positive seals when pumps are lowered into place.
   F. Install sewage pump basins, and connect the drain and vent piping. Brace interior of basins according to manufacturer's written instructions to prevent distortion or collapse during concrete placement. Set basin cover and fasten to basin top flange. Install cover so top surface is flush with finished floor.
   G. Construct sewage pump pits, and connect the drain and vent piping. Set pit curb frame recessed in and anchored to concrete. Fasten pit cover to pit curb flange. Install cover so top surface is flush with finished floor.
   H. Install packaged, submersible sewage pump units, and make direct connections to drainage and vent piping.
   I. Install packaged, wastewater pump unit basins on floor or concrete base unless recessed installation is indicated. Make direct connections to drainage and vent piping.
   J. Support piping so weight of piping is not supported by pumps.
3.4 CONNECTIONS

A. Piping installation requirements are specified in Division 22 Section "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to sewage pumps to allow service and maintenance.

C. Connect sanitary drainage and vent piping to pumps. Install discharge piping equal to or greater than size of pump discharge piping. Install vent piping equal to or greater than size of the pump basin vent connection. Refer to Division 22 Section "Sanitary Drainage and Vent Piping."
   1. Install flexible connectors adjacent to pumps in discharge piping.
   2. Install check and shutoff valves on discharge piping from each pump. Install unions on pumps having threaded pipe connections. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for sanitary waste piping.

D. Ground equipment according to Division 26 Section "Grounding and Bonding."

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checklist according to manufacturer's written instructions.
   2. Verify bearing lubrication.
   3. Disconnect couplings and check motors for proper direction of rotation.
   4. Verify that each pump is free to rotate by hand. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   5. Verify that pump controls are correct for required application.

B. Start pumps without exceeding safe motor power:
   1. Start motors.
   2. Open discharge valves slowly.
   3. Check general mechanical operation of pumps and motors.

C. Test and adjust controls and safeties.
   1. Test every Building Automation System connection for proper operation.
   2. Test every float to ensure proper start and stop of pumps and the signal of alarms.
   3. Ensure call outs to staff are functioning properly.

D. Remove and replace damaged and malfunctioning components.
   1. Pump Controls: Set pump controls for automatic start, stop, and alarm operation as required for system application.
   2. Set field-adjustable switches and circuit-breaker trip ranges as indicated, or if not indicated, for normal operation.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

STORM, CLEARWATER AND SANITARY SEWERAGE PUMPS

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3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 221329
SECTION 221423 - SANITARY, WASTE AND STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following storm drainage piping specialties:
   1. Backwater valves.
   2. Cleanouts.
   3. Floor Drains.
   4. Trench drains.
   5. Channel drainage systems.
   6. Catch basins.
   7. Through Penetration Firestop Assemblies.
   9. Roof drains.
  10. Siphonic Roof Drains.
  11. Miscellaneous Storm Drainage Piping Specialties

B. Related Sections include the following:
   1. Division 07 Section "Sheet Metal Flashing and Trim."

1.2 DEFINITIONS
B. FOG: Fats, oils, and greases.
C. FRP: Fiberglass-reinforced plastic.
D. HDPE: High-density polyethylene plastic.
E. PE: Polyethylene plastic.
F. PP: Polypropylene plastic.
G. PUR: Polyurethane plastic.
H. PVC: Polyvinyl chloride plastic.
I. Grate loading according to ANSI A112.21.1M:
   1. LIGHT DUTY: Pedestrian traffic
   2. MEDIUM DUTY: Light traffic car traffic
   3. HEAVY DUTY: Truck and Semi-Tractor traffic
   4. EXTRA HEAVY DUTY: Forklift traffic

1.3 SUBMITTALS
A. Product Data: For each type of product indicated.

1.4 QUALITY ASSURANCE
A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
   1. BOCA Basic National Plumbing Code.
1.5 SEQUENCING AND SCHEDULING

A. Coordinate the installation of roof drains, flashing, and roof penetrations.
B. Coordinate the installation of drains in poured-in-place concrete slabs, to include proper drain elevations, installation of flashing, and slope of slab to drains.
C. Coordinate with installation of sanitary and storm sewer systems as necessary to interface building drains with drainage piping systems.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Basis of Design: Per the manufacturer listed.
B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

2.2 BACKWATER VALVES
A. Horizontal, Cast-Iron Backwater Valves
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. MIFAB, Inc.
      d. Tyler Pipe; Wade Div.
      e. Watts Drainage Products Inc.
      f. Zurn Plumbing Products Group; Specification Drainage Operation.
   3. Size: Same as connected piping.
   5. Cover: Cast iron with threaded access check valve.
   7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed.
   8. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.
   9. Basis of Design is Zurn Model Z1090

B. Drain-Outlet Backwater Valves
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      c. Watts Drainage Products Inc.
      d. Zurn Plumbing Products Group; Specification Drainage Operation.
   2. Size: Same as floor drain outlet.
   3. Body: Cast iron or bronze made for vertical installation in bottom outlet of floor drain.
   4. Check Valve: Removable ball float.
   5. Inlet: Threaded.
6. Outlet: Threaded or spigot.
7. Cover: Same material as body with threaded access to check valve.
8. Check Valve: Removable swing check.
10. Basis of Design Zurn Model Z1099

2.3 CLEANOUTS

A. Exposed Metal Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. MIFAB, Inc.
      d. Tyler Pipe; Wade Div.
      e. Watts Drainage Products Inc.
      f. Zurn Plumbing Products Group.
      g. Josam Company; Blucher-Josam Div.
   2. Standard: ASME A112.36.2M for cast iron ASME A112.3.1 for stainless steel for cleanout test tee.
   3. Size: Same as connected drainage piping
   4. Body Material: Hub less, cast-iron soil pipe test tee. Stainless-steel tee with side cleanout as required to match connected piping.
   5. Closure: Countersunk or raised-head plug.
   6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Metal Floor Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Oatley.
      c. Sioux Chief Manufacturing Company, Inc.
      e. Tyler Pipe; Wade Div.
      f. Watts Drainage Products Inc.
      g. Zurn Plumbing Products Group.
      h. Zurn Plumbing Products Group.
      i. Kusel Equipment Co.
      k. Josam Company; Blucher-Josam Div.
   2. Standard: ASME A112.36.2M for [adjustable housing] [cast-iron soil pipe with cast-iron ferrule] [heavy-duty, adjustable housing] [threaded, adjustable housing] cleanout.
   3. Size: Same as connected branch.
   4. Type: [Adjustable housing] [Cast-iron soil pipe with cast-iron ferrule] [Heavy-duty, adjustable housing] [Threaded, adjustable housing].
   5. Body or Ferrule: [Cast iron] [Stainless steel]
   6. Clamping Device: [Not required] [Required].
7. Outlet Connection: [Inside calk] [Spigot] [Threaded].
8. Closure: [Brass plug with straight threads and gasket] [Brass plug with tapered threads] [Cast-iron plug] [Plastic plug].
9. Adjustable Housing Material: [Cast iron] [Plastic] with [threads] [set-screws or other device].
10. Frame and Cover Material and Finish: [Nickel-bronze, copper alloy] [Painted cast iron] [Polished bronze] [Rough bronze] [Stainless steel].
11. Frame and Cover Shape: [Round] [Square].
12. Top Loading Classification: [Extra Heavy] [Heavy] [Light] [Medium] Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
15. Size: Same as connected branch.
17. Closure: Stainless steel with seal.
18. Riser: Stainless-steel drainage pipe fitting to cleanout.

C. Plastic Floor Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. IPS Corporation.
      b. NDS, Inc.
      c. Plastic Oddities; a division of Diverse Corporate Technologies.
      d. Sioux Chief Manufacturing Company, Inc.
      e. Zurn Plumbing Products Group; Light Commercial Operation.
   2. Size: Same as connected branch.
   3. Body: PVC.
   4. Closure Plug: PVC.
   5. Riser: Drainage pipe fitting and riser to cleanout of same material as drainage piping.
   6. Basis of Design Sioux Chief Model 852 for 3” and 4” diameter with Nickel Bronze round ring and strainer

D. Cast-Iron Wall Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. MIFAB, Inc.
      d. Tyler Pipe; Wade Div.
      e. Watts Drainage Products Inc.
      f. Zurn Plumbing Products Group.
   2. Standard: ASME A112.36.2M. Include wall access.
   3. Size: Same as connected drainage piping.
   4. Body: Hub less, cast-iron soil pipe test tee as required to match connected piping.
   5. Closure: [Countersunk] [Countersunk or raised-head] [Raised-head], [drilled-and-threaded] [brass] [cast-iron] plug.
   6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

8. Wall Access: [Round] [Square], stainless-steel wall-installation frame and cover.

2.4 FLOOR DRAINS:

A. Floor Drains, Trench Drains, and Roof Drains:

1. Manufacturers: Subject to compliance with requirements, and reference to the drain schedule, provide products by one of the following:
   b. MIFAB, Inc.
   c. Prier Products, Inc.
   e. Tyler Pipe; Wade Div.
   f. Watts Drainage Products, Inc.
   g. Zurn Plumbing Products Group; Light Commercial Operation.
   h. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Floor drain type designations and sizes are indicated on Drawings.

B. Cast-iron body, nickel bronze adjustable strainer head with secured square hole grate, with:

1. Heel-proof grate.
2. Flashing collar for above grade installation.
3. Round strainer head.

C. Cast-iron body, cast iron grate, sediment bucket with:

1. Flashing collar for above grade installation.
2. Trap prime connection, where shown.

D. Cast-iron body, cast iron grate, sediment bucket, wide flange for elastic latex floor covering with:

1. Trap primer connection, where shown.
2. Round top.

E. Cast-iron body, nickel bronze grate with acid resisting enamel interior, flushing connection and hinged grate.

1. Flashing collar for above grade installation.

2.5 TRENCH DRAINS

A. Trench Drains:

1. Manufacturers: Subject to compliance with requirements, and reference to the drain schedule, provide products by one of the following:
   b. MIFAB, Inc.
   c. Plumbing Creations Co.
   e. Tyler Pipe; Wade Div.
f. Watts Drainage Products Inc.
g. Zurn Plumbing Products Group; Specification Drainage Operation.

3. Material: Ductile or gray iron.
4. Flange: [Anchor] [Seepage] [Not required].
5. Outlet: [Bottom] [End] [Side].
6. Grate Material: [Ductile iron] [Ductile iron or gray iron] [Gray iron].
7. Grate Finish: [Painted] [Not required].
8. Dimensions of Frame and Grate: <Insert dimensions and describe body, sump, and grate if required.>
9. Top Loading Classification: [Extra Heavy-Duty] [Heavy Duty] [Light Duty] [Medium Duty].
10. Trap Material: [Cast iron] [Stainless steel] [Not required] <Insert material>.

2.6 CHANNEL DRAINAGE SYSTEMS

A. Stainless-Steel Channel Drainage Systems:
   1. Manufacturers: Subject to compliance with requirements, and referenced to the drain schedule, provide products by one of the following:
      a. Josam Company; Blucher-Josam Div.
      b. MultiDrain Systems.
      c. Zurn Plumbing Products Group; Flo-Thru Operation.
   2. Type: Modular system of stainless-steel channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
      a. Standard: ASME A112.3.1, for trench drains.
      b. Channel Sections: Interlocking-joint, stainless-steel with level invert.
         1) Dimensions: 5.8 inches wide. Include number of units required to form total lengths indicated.
      c. Grates: Manufacturer's designation "heavy duty," with slots or perforations and of width and thickness that fit recesses in channels.
         1) Material: Ductile iron.
         2) Locking Mechanism: Manufacturer's standard device for securing grates to channel sections
      d. Covers: Solid ductile or gray iron, of width and thickness that fit recesses in channels, and of lengths indicated.
      e. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.
      f. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
   3. Type: Modular system of stainless-steel channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
      a. Channel Sections: Interlocking-joint, stainless steel with level invert.
         1) Dimensions: 12 inches wide. Include number of units required to form total lengths indicated.
b. Grates: Manufacturer's designation "heavyduty," with slots or perforations, and of width and thickness that fit recesses in channels.
   1) Material: Ductile iron.
   2) Locking Mechanism: Manufacturer's standard device for securing grates to channel section.

c. Covers: Solid ductile or gray iron, of width and thickness that fit recesses in channels, and of lengths indicated.

d. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.

e. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

B. Polymer-Concrete Channel Drainage Systems:

   1. Manufacturers: Subject to compliance with requirements, as identified in the drain schedule, provide products by one of the following:
   a. ABT, Inc.
   b. ACO Polymer Products, Inc.
   c. Josam Company; Mea-Josam Div.

   2. Type: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
      a. Channel Sections: Narrow, interlocking-joint, sloped-invert, polymer-concrete modular units with end caps. Include rounded bottom, with built-in invert slope of 0.6 percent and with outlets in number, sizes, and locations indicated. Include extension sections necessary for required depth.
         1) Dimensions: 4-inch inside width. Include number of units required to form total lengths indicated.
         2) Frame: [Gray-iron or galvanized steel for grates] [Not required].
      b. Grates: Manufacturer's designation "heavy [medium]" duty," with slots or perforations, and of width and thickness that fit recesses in channel sections.
         1) Material: Ductile iron [Stainless steel].
         2) Locking Mechanism: [Manufacturer's standard device for securing [heavy] [medium] gratess to channel sections] [Not required].
      c. Covers: Solid ductile or gray iron, of width and thickness that fit recesses in channel sections, and of lengths indicated.
      d. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.
      e. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
      f. Channel Sections: Narrow, interlocking-joint, precast, polymer-concrete modular units with end caps. Include rounded bottom, with level invert and with NPS 4 (DN 100) outlets in number and locations indicated.
         1) Dimensions: 5-inch inside width and 9-3/4 inches deep. Include number of units required to form total lengths indicated.
         2) Frame: [Gray-iron or galvanized steel for gratess] [Not required].
      g. Grates: Manufacturer's designation "heavy [medium]" duty," with slots or perforations, and of width and thickness that fit recesses in channel sections.
1) Material: [Ductile iron] [Galvanized steel] [Gray iron] [Stainless steel].
2) Locking Mechanism: [Manufacturer's standard device for securing grates to channel sections] [Not required].

h. Covers: Solid [ductile or gray iron] <Insert material>, of width and thickness that fit recesses in channel sections, and of lengths indicated.

i. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.

j. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

k. Channel Sections: Wide, interlocking-joint, precast, polymer-concrete modular units with end caps. Include flat or rounded bottom, with level invert and with outlets in number, sizes, and locations indicated.

1) Dimensions: 8-inch inside width and 13-3/4 inches deep. Include number of units required to form total lengths indicated.
2) Frame: [Gray-iron or galvanized steel for grates] [Not required].

l. Grates: Manufacturer’s designation "[heavy] [medium] duty,” with slots or perforations and of width and thickness that fit recesses in channel sections.

1) Material: [Ductile iron] [Galvanized steel] [Gray iron] [Stainless steel].
2) Locking Mechanism: [Manufacturer's standard device for securing grates to channel sections] [Not required].

m. Covers: Solid [ductile or gray iron] <Insert material>, of width and thickness that fit recesses in channel sections, and of lengths indicated.

n. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.

o. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

C. Plastic Channel Drainage Systems:

1. Manufacturers: Subject to compliance with requirements, as identified in the drain schedule, provide products by one of the following:
   a. Infinity Plastics, Inc.
   b. NDS Inc.
   c. Smith, Jay R. Mfg Co.; Division of Smith Industries, Inc.
   d. Zurn Plumbing Products Group.
   e. ACO Polymer Products, Inc.
   f. Josam Company.

2. Type: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.

   a. Channel Sections: Interlocking-joint, HDPE or PP modular units, with end caps. Include flat, rounded, or inclined bottom, with level invert and with outlets in number, sizes, and locations indicated.

      1) Dimensions: 4 inches (102 mm) wide. Include number of units required to form total lengths indicated.

   b. Grates: With slots or perforations and widths and thickness that fit recesses in channel sections.
1) Material: Galvanized steel or Stainless steel as indicated in the drain schedule
   c. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.
   d. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

2.7 CATCH BASINS
   A. Polymer-Concrete Catch Basins:
      1. Description: 24-by-12-inch, precast, polymer-concrete body, with outlets in number and sizes indicated. Include gray-iron slotted grate.
      2. Frame and Grate: Galvanized steel for grate as indicated in the drain schedule.

2.8 THROUGH-PENETRATION FIRESTOP ASSEMBLIES
   A. See Division 7 for Fire stop assemblies.

2.9 GREASE INTERCEPTORS
   A. Manufacturers: Subject to compliance with requirements, provide products as identified in the drain schedule by one of the following:
         a. MIFAB, Inc.
         b. Prier Products, Inc.
         d. Tyler Pipe; Wade Div.
         e. Watts Drainage Products Inc.
         f. Zurn Plumbing Products Group.
   B. Standard:
      1. NSF International, (National Sanitation Foundation), including PDI -G101.
         a. Steel Interceptor with Gray Duco Coating Inside and Outside with Steel Cone, Draw-off Hose and Cap, Line Shut-off Valve and Flow Control Fitting.
      2. Body Material: Coated Steel.
      3. Dimensions of Body: Insert dimensions and describe body and sump if required.
      4. Inlet and Outlet:
      5. Extension Collars: Not required [Required].

2.10 ROOF DRAINS
   A. Metal Roof Drains:
      1. Manufacturers: Subject to compliance with requirements, provide products as identified in the drain schedule by one of the following:
         a. Retain one of three lists of manufacturers below.
         b. Josam Company; Josam Div.
         c. MIFAB, Inc.
         d. Prier Products, Inc.
2. Standard: ASME A112.21.2M.
3. Pattern: [Balcony] [Canopy] [Cornice] [Promenade-deck] [Roof] [Scupper] drain.
5. Dimensions of Body: <Insert dimensions and describe body and sump if required.>
6. Combination Flashing Ring and Gravel Stop: [Not required] [Required].
7. Flow-Control Weirs: [Not required] [Required].
8. Outlet: [Bottom] [Side] [Angle].
10. Extension Collars: [Not required] [Required].
11. Underdeck Clamp: Required.
12. Sump Receiver: [Not required] [Required].
13. Basis of design model Zurn Z100 15” low silhouette cast iron dome.

2.11 SIPHONIC ROOF DRAINS
A. Metal Roof Drains:

   1. Manufacturers: Subject to compliance with requirements, provide products as identified in the drain schedule by one of the following:

      a. Retain one of three lists of manufacturers below.
      b. MIFAB, Inc.
      d. Zurn Plumbing Products Group.

   2. Standard: ANSI/ASTM 112.6.9
   3. Pattern: Roof drain.
   5. Dimensions of Body: <Insert dimensions and describe body and sump if required.>
   6. Combination Flashing Ring and Gravel Stop: [Not required] [Required].
   7. Flow-Control Weirs: [Not required] [Required].
   8. Outlet: [Bottom] [Side] [Angle].
   10. Extension Collars: [Not required] [Required].
   11. Underdeck Clamp: [Required].
   12. Sump Receiver: [Not required] [Required].

2.12 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES
A. Expansion Joints:

   1. Standard: ASME A112.21.2M.
   2. Body: Cast iron with bronze sleeve, packing, and gland.
   3. End Connections: Matching connected piping.
   4. Size: Same as connected piping.
   5. Basis of Design Zurn Model Z190.

B. Downspout Boots:

   1. Description: Manufactured, ASTM A 48/A 48M, gray-iron casting, with strap or ears for attaching to building; NPS 4 outlet; and shop-applied bituminous coating.
2. Size: Inlet size to match downspout.
3. Description: ASTM A74, Service class, hub-and-spigot, cast-iron soil pipe.
4. Size: Same as or larger than connected downspout.

C. Conductor Nozzles:
1. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.
2. Size: Same as connected conductor.

2.13 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES
A. Open Drains (Hub Drains):
1. Material: PVC Schedule 40 piping.
2. Size: Same as connected waste piping with an increaser fitting of the size indicated on Drawings.
3. Rim to be 2 inches above finish door.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Refer to Division 22 Section "Basic Division 22 Requirements" for piping joining materials, joint construction, and basic installation requirements.
B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
   1. Size same as drainage piping up to NPS 6. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate at each change in direction of piping per Wisconsin plumbing code SPS 382.35.
   3. Locate at minimum intervals per Wisconsin plumbing code SPS 382.35
   4. Locate at base of each vertical soil and waste stack.
   5. Locate wall cleanouts at all water closets. Single cleanouts may be used for ganged water closets on the same waste branch.
   6. Identify pipe system served by each cleanout by providing label under cleanout cover.
C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
E. After completion of flooring work, ensure that each floor drain is sealed with floor safing material.
F. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface, unless otherwise indicated.
G. Assemble and install ASME A112.3.1, stainless-steel channel drainage systems according to ASME A112.3.1. Install on support devices so that top will be flush with surface.
H. Assemble non-ASME A112.3.1, stainless-steel channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.
I. Assemble FRP channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.

J. Assemble plastic channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.

K. Install through-penetration firestop assemblies in plastic [conductors] [and] [stacks] at floor penetrations.

L. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 07.
   1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
   2. Position roof drains for easy access and maintenance.

M. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

N. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

O. Install manufactured, gray-iron downspout boots at grade with top 18 inches above grade. Secure to building wall.

P. Install cast-iron soil pipe downspout boots at grade with top of hub 18 inches above grade.

Q. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.

R. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221423
SECTION 221424 – SANITARY WASTE VACUUM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 PERFORMANCE REQUIREMENTS
A. EOR STANDARD.

1.3 SUBMITTALS
A. Product Data: For each type of product indicated.

1.4 QUALITY ASSURANCE
A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
   1. BOCA Basic National Plumbing Code.

1.5 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum ten years documented experience.
B. Installer: Company specializing in performing the work of this section with minimum two years documented experience.

1.6 VACUUM SYSTEM DESIGN DOCUMENTS AND BID QUALIFICATIONS
A. The vacuum waste system contract documents have been prepared to insure that the owner takes custody of a properly functioning vacuum drainage system at the conclusion of system commissioning. For that reason, all proposals or quotations for this portion of the project must include a document, signed by an officer of the vacuum system manufacturer, certifying that the vacuum drainage system being offered is in compliance with the performance criteria outlined in the plans and specifications with regard to vacuum pump size, type and quantity, waste collect tank type, size, quantity; materials of construction; vacuum center control hardware and operational strategies; vacuum waste valve control and operational strategies; vacuum waste valve orientation; and vacuum pipe sizes and routing.

B. For any proposal or quotation that deviates from the plans and specifications to be considered, it must be submitted in writing to the Engineer of Record and Owner for review. The alternative proposal must include supporting documentation clearly outlining the areas of nonconformity, and must include a detailed justification and rationalization for the recommended deviations. The alternative proposal must provide a full description of all deviations, alterations, changes to control strategies, and revised protocols as well as drawings, calculations, and explanations as may be necessary for the Engineer and Owner to fully evaluate the recommended changes. Quotations not in compliance with the project documents received less than two weeks in advance of the bid date will not be considered.
C. Should the Engineer and Owner agree to any changes to the scope of the vacuum drainage system design or operation as outlined in the original design documents, all costs associated with the redesign or impact on the project’s documents and schedule will be borne by the entity submitting the deviation request. In addition, all bidders who submitted proposals in compliance with the design documents, should they so choose, will be allowed two weeks to prepare an alternative quotation that responds to the revised vacuum plumbing system scope.

PART 2 - PRODUCTS

2.1 VACUUM PLUMBING SYSTEM - GENERAL

A. The Vacuum Plumbing Systems shall consist of a complete system of waste collection tanks, vacuum pumps, system controls, vacuum drainage and flush valve assemblies, waste accumulators, and vacuum waste piping network. The system shall be installed so that a single collection tank, or any of the vacuum pumps can be removed from operation and serviced without reducing the system’s capacity (minimum redundancy N+1).

B. AcornVac is the basis of design for all major components including vacuum pumps, tanks, vacuum drainage and flush valve assemblies. The vacuum drainage piping network shall be furnished and installed by the division 22 contractor in accordance with specification requirements and installation guidelines as further outlined. The system shall be in compliance with vacuum plumbing system manufacturer’s installation requirements.

C. The completed system shall be tested, and ready for operation. For any technical questions regarding installation of the system, or clarification of components furnished contact:

   AcornVac, Inc.
   13818 Oaks Avenue
   PH: 1-800-591-9920
   FX: 1-809-902-5041
   Attn: Technical Assistance Department
   Email: tzinn@acornvac.com

D. The Installing plumbing contractor and AcornVac, Inc. shall coordinate as described herein, to ensure that the Installing plumbing contractor is fully aware of all installation requirements, and without exception to required techniques, materials, and configurations that are unique to vacuum waste systems as described in contract drawings and documents, and that the installation is completed in accordance with these drawings and contract documents.

2.2 VACUUM WASTE PIPE AND FITTINGS

A. Vacuum drainage piping and fittings shall be in compliance with local plumbing codes and shall be smooth internal bore, rated for 100% vacuum pressure. Acceptable materials: 1) Pressure rated, Schedule 40 PVC with DWV pattern fittings for directional changes, 2) Type “L” copper pipe and DWV pattern fittings, or 3) Schedule 10 vacuum rated stainless steel pipe and DWV pattern fittings. Valves shall be installed so that they are easily accessible for future inspection and maintenance.

B. All vacuum piping shall be installed in accordance with contract drawings and documents.
2.3 VACUUM VALVE EQUIPMENT AND CONTROL

A. Vacuum valve assemblies shall be furnished by AcornVac, Inc. and installed by the Division 22 contractor as shown on the plans. An assembly shall be provided for each point in the facility where wastewater must be collected, removed and transported to the Vacuum Center for disposal in a sanitary waste line.

B. Each collection point shall include components furnished by AcornVac, Inc. and installed by the Division 22 contractor and include the following but are not limited to; a Zone Control electronic vacuum valve controller, a vacuum waste Extraction Valve which isolates atmospheric pressures at the toilet bowl or accumulator from the vacuum piping network, a mini check valve assembly, and a sufficient length of flexible vacuum rated tubing to interconnect the active vacuum components.

C. Extraction Valves shall meet the following minimum requirements:
   1. Extraction Valves shall be of the normally closed tubular diaphragm type.
   2. Extraction Valves shall provide a fully open, unobstructed passageway between the accumulator and vacuum piping network at a vacuum pressure of twelve (12) inches Hg.
   3. Extraction valves shall provide a bubble tight seal between atmospheric pressure and vacuum pressure in the piping network when at rest.
   4. Extraction valves shall include an integral vacuum source port.
   5. Extraction valve shall include a strain relief bracket for connection of the vacuum tubing.

D. Pipe Accumulator shall be installed where shown on the plans and shall act as temporary storage vessels for waste liquids. Small Volume Accumulators shall be field fabricated and installed by the Division 22 contractor as shown on the plans. Refer to Pipe Accumulator Schedule on plans.

E. Box and Sump Accumulators shall be facilitated from stainless steel by the vacuum system supplier and installed by the contractor as shown on the plans.

F. AcornVac Vacuum Rated Toilets shall be as per the equipment schedule.

2.4 ZONE CONTROL PANELS, LIFT STATION INTERFACE PANELS, AND LIFT STATIONS

A. Waste removal from the fixtures shown on the contract documents shall be accommodated by AcornVac Zone Control Panels, Lift Station Interface Panels, and Lift Stations. Each Zone Control Panel shall be capable of operating up to twelve (12) Lift Stations, and four (4) configurable solenoid valves (or 12 toilet flush valves).

B. Each Zone Control Panel shown on the plans shall require a 120VAC, 3 amp power source, and shall consist of the following:
   1. NEMA 4/12 industrial enclosure.
   2. Individual power circuit breakers for the PLC and DC power supply.
   3. Clearly marked and numbered terminal strips for connection to each Lift Station Interface panel and grease accumulator.
   4. 24VDC Power Supply suitable for operation of 12 Lift Stations and 4 programmable valves (or 12 toilet flush valves).
   5. Programmable Logic Controller (PLC) with operational logic for 12 Lift Stations and 4 programmable valves (or 12 toilet flush valves).
   6. Ethernet communication module for interface with the Vacuum Center Control Panel.
7. Communication wiring between the each Zone Control Panel and the Vacuum Center control panel shall be by means of Category 5e Ethernet cable provided and installed by the contractor.

C. A Lift Station Interface Panel assembly shall be provided for each Lift Station and shall serve as the electrical and pneumatic interface between the Lift Station components and Zone Control Panel. Each Lift Station Interface Panel shall consist of the following:

1. 16Ga, Galvanized steel enclosure with removable cover.
2. Clearly marked terminal strip for connecting each Lift Station Interface panel to its’ associated Zone Control Panel.
3. Digital Translator for monitoring Lift Station accumulator fill level status.
4. Solenoid valve to operate the Lift Station extraction valve.
6. Barb-to-Tube connectors for connection of the Lift Station interface to the extraction valve and vacuum source for the lift.
7. Wiring between each Lift Station Interface Panel and its’ associated Zone Control Panel shall be by means of an 18ga conductor consisting of two (2) twisted shielded pairs. The conductor shall be provided and installed by the contractor.

D. Lift Stations shall be provided for each point in the facility where waste must be collected, removed, and transported to the Vacuum Center for eventual disposal in a sanitary waste line.

1. Each Lift Station shall consist of an Extraction Valve, Mini check valve, Lift Station Interface panel, toilet or accumulator, and a sufficient length of flexible vacuum rated tubing to interconnect the active vacuum components. The accumulator can be sourced from AcornVac, or field fabricated as noted on the project drawings. The Lift Station Interface Panel and Zone Control Panel operate together to determine when sufficient waste has been collected in an accumulator for removal. The active vacuum components shall consist of:
   a. Extraction Valve
      1) Extraction Valves shall be provided by AcornVac and installed by the contractor as shown on the contract documents and the most current version of the AcornVac Design Manual.
      2) Extraction Valves shall be of the normally closed tubular diaphragm type.
      3) Extraction valves shall provide a bubble tight seal between atmospheric pressure in the accumulator and vacuum pressure in the piping network when at rest.
      4) Extraction valves shall include an integral vacuum source port for connection to the Lift Station Interface Panel via the Mini Check Valve.
      5) Extraction valve shall include a strain relief bracket for connection of the vacuum tubing.
   b. Mini check valve to prevent migration of liquids into the vacuum source line and solenoid valve.
   c. Swing Check Valve, installed at the top of Lift Station risers where shown on the plans (as applicable). Each Swing Check Valve shall be vacuum rated and manufactured from transparent materials that allow operating personnel to view its operation without removal from the piping network. Swing Check Valves shall also allow the isolating diaphragm to be easily serviced or replaced without modification to the piping.
d. Grey water accumulators shall be installed by the contractor where shown on the plans and shall act as temporary storage vessels for the waste liquids. Accumulators shall be field fabricated or manufactured by the vacuum system supplier as shown on the plans.

E. Each Zone Control Panel shall communicate to the Vacuum Center Control Panel and Operator Interface Panel (OIT) via the Ethernet network.

1. The Vacuum Center shall share its vacuum pressure with each Zone Control Panel on the network.
2. Alarms shall be provided at the Vacuum Center OIT to advise of any communication failure between the Zone Control Panels and the Vacuum Center Control Panel.

F. Each Zone Control Panel shall provide the following control strategies. These strategies shall be individually configurable for up to twelve (12) Lift Stations and four (4) programmable solenoid valves (or 12 toilet flush valves) as further outlined below:

1. Each lift station shall be programmable to act in accumulator mode or toilet mode.
2. Normal Lift Station Operation – Accumulator Mode
   a. When configured for Accumulator Mode, activation shall occur when the device which monitors the accumulator fill level determines that it is sufficiently full to require removal of the collected waste. When the discharge cycle is initiated, it shall open the associated extraction valve and keep it open so long as the accumulator fill level activation signal is present or is shut down and transfers to the failsafe mode of operation. When the activation signal is removed, the extraction valve shall continue to be held open for an operator adjustable time period.

3. Normal Lift Station Operation – Toilet Mode
   a. When configured for Toilet Mode, activation shall occur when the toilet flush button is depressed. This action will take place only once and the lift will operate for its adjustable time period. It will not re-activate until the flush button is released and depressed once again. The flush valve for the toilet shall one of the assigned programmable valves specifically designed for vacuum toilet applications as noted on the contract drawings.

4. Lift Activation Permissive
   a. Lift activation shall only occur if the selected permissive device and any associated setpoints are satisfied. The operator shall be able to select the permissive to be used by the Lift Activation logic from the Vacuum Center OIT as follows:
      1) No Permissive required. Lift shall activate when commanded regardless of system vacuum pressure.
      2) Vacuum Center vacuum pressure transducer (shared via the Ethernet communication network). The operator shall be able to adjust the permissible activation pressure from the Vacuum Center OIT.
         a) The operator shall be able to adjust the amount of time that the permissive must be present before the Lift Activation cycle is initiated.
         b) If the Vacuum Center vacuum transducer is selected as the permissive source, and communications are lost between the Vacuum Center and Zone Control Panel, the Lift will activate as if No Permissive has been selected until communications are re-established.
3) Lift Activation Timeout
   a) The amount of time that a Lift remains active once the activation signal has cleared, or the toilet flush button is depressed, shall be selectable between Manual and Automatic at the Vacuum Center OIT. In Manual, the Timeout setpoint shall be fixed by the operator. In Automatic, the Timeout setpoint shall be calculated by an optimizing algorithm which determines the most efficient value for the Lift based on the active vacuum pressure in the system at the time the Lift Cycle commences.
   b) The Automatic Timeout setpoint shall be calculated using four operator adjustable parameters. The optimizing algorithm shall compute a linear Timeout value within the boundaries of these setpoints as follows:
      I. Minimum Pressure – establishes the minimum vacuum pressure (sourced from the Vacuum Center) at which the Maximum Timeout setpoint is used.
      II. Maximum Timeout setpoint – establishes the Maximum Timeout value when the vacuum pressure is at or below the Minimum Pressure setpoint.
      III. Maximum Pressure – establishes the maximum vacuum pressure at which the Minimum Timeout setpoint is used.
      IV. Minimum Timeout setpoint – establishes the Minimum Timeout value when vacuum pressure is at or above this Maximum Pressure setpoint.
   c) The active Lift Station Timeout setpoint will automatically revert to the Manual setpoint if communications between the affected Zone Control Panel and Vacuum Center are interrupted for any reason. The optimized setpoint shall be automatically restored when communications are restored.

5. Programmable Solenoid Valves
   a. Each Zone Control Panel shall be capable of operating four (4) independent and fully programmable solenoid valves (or 12 toilet flush valves) that can be assigned to any of the twelve (12) lift stations. Control strategies shall be provided to allow each of these valves to act as any one of the following:
      1) An accumulator rinse valve
      2) A toilet flush valve
      3) A temperature control valve
      4) A water supply safety valve

G. The following Zone Control OIT functions shall be provided for each Zone Control Panel
   1. General Zone Control Panel and Lift Station Overview screen to provide:
      a. Visual indication of the ON-OFF status of all Lift Stations enabled and configured for all Zone Control panels.
      b. Manual activation of any Lift Station enabled and configured for any Zone Control Panel.
      c. Visual indication of alarms that are active in the Zone Control Panel.
      d. Access to any Zone Control Panel overview screen.
      e. Visual indication of the Vacuum Center vacuum pressure.
2. Individual Zone Control Overview and Status screen:
   a. Visual indication of the Zone Control Panel's communication status with the Vacuum Center.
   b. Visual indication of the Lift Station status for any Lift Station configured for the Zone Control Panel.
   c. Access to the ZCP Setup Screen(s).
   d. Reset button for Zone Control Panel communication alarm with Vacuum Center.
   e. Reset button for all active Zone Control Panel alarms.

3. Individual Zone Control Panel Setup and Configuration screen:
   a. Selector for the Zone Control Panel Lift permissive source.
      1) None
      2) Vacuum Center transducer pressure
   b. Enable/Disable selector for each of the twelve (12) Lift Stations configurable for the Zone Control Panel.
   c. Access to the programmable solenoid valve setup screens.
   d. Ability to load factory default setpoints in any lift in any zone panel by the press of a single button.

H. The following screens and functions shall be provided for EACH Lift Station within a Zone Control panel.

1. Lift Station Overview Screen
   a. Show activation status of the Lift Station.
   b. Allow for manual activation of a Lift Station.
   c. Allow for Auto/Manual selection of the Timeout setpoint - tenths of seconds resolution.
   d. Display the active vacuum pressure being communicated by the Vacuum Center.
   e. Display the calculated Timeout setpoint.
   f. Allow for adjustment of the Manual Timeout setpoint.
   g. Display the Failsafe Mode status.
   h. Allow the Failsafe Mode to be manually invoked.
   i. Allow the Failsafe Mode to be automatically invoked.
   j. Allow the Failsafe Mode to be set to off.
   k. Allow the ON TOO LONG alarm feature to be Enabled or Disabled.
   l. Display the status of the ON TOO LONG alarm feature.
   m. Display the status of any Communication Failure with the Vacuum Center
   n. Display the total number of Lift Station activations since the system was commissioned.

2. Lift Station Setpoint configuration and adjustment screen.
   a. Provide adjustment of the Minimum Activation Pressure - tenths of Inches Hg resolution
   b. Provide adjustment of the Low Activation Pressure Delay - tenths of seconds resolution.
   c. Provide adjustment of the INPUT ON TOO LONG alarm delay - seconds resolution.
   d. Provide adjustment of the FAILSAFE WAIT INTERVAL - minutes resolution.
   e. Provide adjustment of the Calculated Timeout Minimum Pressure - tenths of inches Hg resolution.
f. Provide adjustment of the Calculated Maximum Timeout Runtime - tenths of seconds resolution.
g. Provide adjustment of the Calculated Maximum Timeout Pressure - tenths of inches Hg resolution.
h. Provide adjustment of the Calculated Minimum Timeout Runtime - tenths of seconds resolution.
i. Display the active Vacuum Pressure being transmitted by the Vacuum Center.
j. Display the Calculated Timeout setpoint.

3. Lift Station Programmable Solenoid Valve Setup (typical for each of 4 or 12 valves)

a. Allow each valve to be configured for a specific mode of operation

1) None
2) Rinse
3) Temperature Control
4) Flush Valve
5) Safety Valve

b. Once the mode assignment is complete, allow each valve to be configured for the specific mode of operation as follows:

1) None
   a) Valve not assigned or configured for use
2) Rinse
   a) Assign the Lift number which the valve is to follow. The solenoid valve shall activate any time the lift activates.
   b) Allow the rinse valve to be operated for a period of time between lift activations by assigning a rinse schedule and duration.
   c) Allow the rinse valve to be operated on after a specified count of lift activations.
   d) All the rinse valve to be automatically turned off if a High Level in the accumulator occurs.
3) Flush Valve (typical for each the 12 toilet flush valves)
   a) Assign the lift number which the flush valve is to follow. The solenoid valve shall activate any time the lift activates.
   b) Establish the toilet bowl refill duration.
4) Temperature Control Valve
   a) Assign the lift number which the temperature control valve is to follow.
   b) Assign the analog input channel the control strategy is to use for the temperature control function.
   c) Enable/Disable the associated extraction valve if the vessel temperature exceeds a programmed high temperature value.
   d) Assign the temperature control strategy to be employed – heating or cooling.
   e) Deactivate the valve if the vessel is experiencing a high-level alarm.
   f) Activate the valve based on the measured temperature.
   g) Establish the heating or cooling start setpoint.
   h) Establish the heating or cooling offset stop setpoint.
   i) Enable/Disable activation of the heating valve when the lift activates.
2.5 VACUUM CENTER

A. The Vacuum Center shall consist of collection tanks, water sealed liquid ring vacuum pumps, electrical control panel, and ancillary equipment for full automatic, on-demand, operation of the system.

B. LIQUID RING VACUUM PUMPS

1. AcornVac, Inc. shall furnish complete water sealed liquid ring vacuum pump packages as further described herein and indicated on the equipment schedule.

2. Each vacuum pump package shall be fully assembled and shall include a fabricated structured steel frame to support the pump and associated accessories. Each pump package shall include an integral separator tank.

3. Each vacuum pump shall be oil free, positive displacement, liquid ring type using water as the sealant fluid. The vacuum pump shall be of the flat port, single stage design with vertical inlet and discharge ports. Each vacuum pump shall have a capacity as indicated on the equipment schedule.

4. The vacuum pump packages shall be furnished by AcornVac, Inc. and each shall include the following:
   a. Integral separator pressure relief valve
   b. Separator level indicator
   c. An air cooled heat exchanger
   d. A built-in condenser
   e. Anti-siphon valve
   f. The external water supply shall meet the following minimum criteria:
      1) Minimum pH: 7
      2) Maximum Chlorides: 10 ppm
      3) Maximum Total Dissolved Solids: 200 ppm
      4) Maximum Hardness: 200 ppm
   g. Inlet check valve for each pump.
   h. Maximum space temperature in the area of the pumps shall be maintained with a temperature range of 40°F-90° F.

5. The installing contactor shall provide a service disconnect for each pump as shown on the plans and as required by local codes

C. GRINDERS

1. General
   a. AcornVac shall furnish one (1) 5HP in-line grinder package.
2. Products
   a. Each grinder shall include cutters, spacers, shafts, bearings and seals, in-line housing with pipe flanges, inspection ports, cutter stack, reducer, and motor.
   b. The cutter cartridge and drive assembly shall be removable from the main housing as a complete assembly without further disassembly. The components of that assembly include cutters, spacers, shafts, reducer, motor, bearings, and seals.
   c. The grinder shall be of two (2) -shaft design and be capable of continuous operation, processing wet or dry. Grinders designed with cutter and spacer cartridges rather than individual cutters and spacers, shall not be acceptable. Single shaft devices utilizing a single rotating cutter bar with stationary cutters shall not be acceptable.
   d. Two-shaft design shall consist of two parallel shafts alternately stacked with individual intermeshing cutters and spacers positioned on the shaft to form a helical pattern. The two shafts shall counter-rotate with the driven shaft operating at approximately two-thirds (2/3) the speed of the drive shaft.

3. Components
   a. Individual Cutters and Spacers
      1) Individual cutters and spacers shall be 4130 heat treated alloy steel, surface ground for uniformity and through-hardened to a minimum 45-50 Rockwell.
      2) The inside configuration of both the individual cutters and the individual spacers shall be hexagonal so as to fit the shafts with a total clearance not to exceed 0.015 inch (0.38 mm) across the flats to assure positive drive, minimize wear on the cutters, and increase the compressive strength of the spacers.
      3) Cutter configuration shall consist of individual 11 tooth cam cutters on both shafts. To maintain particle size, the height of the tooth shall not exceed 1/2 inch (13 mm) above the root diameter. Cutter to cutter root diameter overlap shall be not less than 1/16 inch (1.6 mm) or greater than 1/4 inch (6 mm) to maintain the best possible cutting efficiency while incurring the least amount of frictional losses. Clearance between overlapping cutters of opposing shafts shall be no greater than 0.011 inches (0.28 mm).
      4) The cutters shall exert a minimum force at the tooth tip of 2,051 lbs./hp (12,234 N/kW) during momentary load peaks.
   b. Shafts
      1) Grinder drive and driven shafts shall be made of 4140 heat treated hexagon steel with a tensile strength rating of not less than 149,000 psi (1,027 kPa).
      2) Each hexagonal shaft shall measure a nominal two (2) inches (51 mm) across parallel surfaces.
   c. Intermediate Shaft Support
      1) An intermediate shaft support shall be provided in the center of the cutter stack for all grinders with 24-inch (610 mm) cutter stacks.
      2) The intermediate shaft support shall provide additional support for heavier than normal influent grinder demand loads and protection for the seal assemblies.
      3) The intermediate shaft support shall be made of a cast 303 stainless steel collar and two (2) bushings. The bushings shall act as bearings to allow the free rotation of the shafts.
   d. Main Housing and Covers
1) The main housing shall be a solid cast structure made of A536-84 ductile iron. The one-piece flanged body shall be capable of remaining in-line if removal of the cutter cartridge and drive assembly is required for service.

2) The inside profile of the main housing shall be concave to follow the radial arc of the cutters. To direct larger particles toward the cutters and assure fineness of grind, the main housing shall maintain a clearance not to exceed 5/16 inch (8 mm) between the major diameter of the cutter and the concave arc of the housing.

3) The main housing shall be provided with a covered access port for equipment inspection. Inspection port covers shall be A536-84 ductile iron.

e. Shaft Bearings and Seals
   f. The radial and axial loads of the cutter shafts shall be borne by sealed, oversized, deep-groove ball bearings at each end.
   g. The bearings shall be protected by a combination of a replaceable and independent tortuous path device and mechanical seals.
   h. Face materials shall be tungsten carbide to tungsten carbide.
   i. O-rings shall be made of Buna-N elastomers.
   j. Products requiring continuous or occasional lubrication or flushing shall not be accepted.
   k. The mechanical seal shall be rated at 90 psi (620 kPa) continuous duty by the seal supplier.
   l. The bearings shall be housed in a replaceable cartridge that supports and aligns the bearings and seals, as well as protects the shafts and end housings. The seal elements shall be independent of the stack height; therefore, cutter stack tightness shall not affect seal performance. The seal elements shall maintain their factory set preload independent of the cutter stack tightness.
   m. Seals shall meet required pressure rating regardless of cutter stack fit. The seal cartridge shall provide seal protection against axial loading on shafts and bearings during shaft deflection.
   n. Each seal element shall be positively locked to its corresponding rotating or static cartridge element. This positive lock on the seal elements is critical to long seal life in applications where grit or other abrasive materials are present.
   o. Gear Housing and Cover
      1) The gear housing shall be provided with a covered access port for cutter stack tightening.
      2) The gear housing shall be A536-84 ductile iron.
      3) The cutter stack tightening cover shall be A36 carbon steel.
   p. Reducer
      1) The speed reducer shall be a grease-filled planetary-type of reducer with a 500% shock load capacity. The reduction ratio shall be 29:1.
      2) The input shaft of the reducer shall be directly coupled to the motor using a three (3)-piece coupling, and the output shaft of the reducer shall be directly coupled with the grinder using a two (2)-piece coupling.
   q. Motor
      1) The motor shall be 5 hp, TEFC, 1,725 rpm, 230/460 volt, 3 phase, 60 Hz.
      2) Motor service factor shall be 1.15, the efficiency factor not less than 85% at full load and the power factor not less than 80% at full load.
D. WASTE COLLECTION TANKS
1. CAPACITY: AcornVac shall furnish waste collection tanks, each with volume capacity as per the equipment schedule.
2. CONSTRUCTION: Stainless Steel.
3. WORKING PRESSURE: 0 – 29.9 inches Hg. vacuum pressure.

E. VACUUM WASTE SYSTEM CONTROLS
1. AcornVac shall furnish, for installation by division 22 contractor, a Vac Center Control Panel as specified herein and as shown on the contract drawings.
2. The vacuum center control panel shall be sized and outfitted to operate up to 4 identically sized pumps in order to allow for future expansion. The panel shall be complete with all electrical gear and software required to operate 4 pumps.

F. PROCESS CONTROL FOR VACUUM PUMPS, WASTE EJECTION PUMPS, AND STORAGE TANKS
1. The Vac Center Control Panel shall include a Programmable Logic Controller (PLC), Operator Interface Terminal (OIT), power supplies and components necessary to automatically sequence the vacuum pumps and discharge pumps as further described herein.
2. Vacuum pressure transducer shall be provided for the common vacuum header connecting the vacuum pumps to the storage tanks. This instrument shall be used for display, control, and alarm purposes.
3. All Pump and Tank control strategies shall be implemented in a Programmable Logic Controller (PLC) which includes sufficient ports to allow the PLC to simultaneously communicate with the local Operator Interface Terminal (OIT) and other external devices.
4. The AUTO position for each pumps’ Hand-Off-Auto selector switch shall be monitored by the Programmable Logic Controller to determine if a pump is in service and may be automatically sequenced. The MANUAL position of the selector switch shall be wired directly to the pump start circuit to insure that a unit can run independent of the PLC.
5. An Operator Interface Terminal (OIT) shall be mounted on the panel door. This unit shall provide the following minimum functions:
   a. Display the system status.
   b. Display historical system performance.
   c. Display all alarm statuses.
   d. Display, and allow adjustment of, all operational setpoints. All setpoints are to be fully described to the extent reasonable for the display device and presented in engineering units easily understandable by the operator. Where applicable setpoint upper and lower limits shall be incorporated to prevent setpoints from being inappropriately modified.
6. A common alarm light shall provide indication that alarms are active.
7. Four (4) Form A unpowered relay outputs will be furnished for connection to the facilities alarm monitoring system. The OIT shall allow any alarm generated by the control panel to be assigned to any of these alarm contacts.
8. Remote Access Capability - the control system shall be designed such that Ethernet communication can be easily installed at any time. Selection of either type shall not exclude the use of the other:
9. Basic Control Strategies
   a. Waste Collection Tanks
1) The waste collection tanks shall be capable of simultaneously collecting or discharging waste products.

2) Each tank shall be provided with a High-Level alarm.

3) Start-stop setpoint for Ejection pump control.

4) Provision shall be included to remove a tank from service. When removed, its alarm and control features will be disabled, and it will no longer be included in the storage control strategy.

b. Vacuum Pumps

1) The vacuum pumps shall be staged on and off according to demand in the system as recorded by the vacuum pressure transducer.

2) An alternation strategy shall be employed which equalizes the running time of the pumps.

3) Each pump shall be provided with a water management strategy which maintains the correct water level in its separator tank, and discharge air temperature.

4) The system shall monitor the status of the emergency power equipment and allow the operating personnel to determine how many pumps will operate with the system is running on emergency power.

5) When the system is running on emergency power, pump staging shall cease and the number of pumps specified at the OIT for this condition shall run continuously.

10. Interface with the Zone Control Panels

a. The vacuum center control panel shall provide for connection to each of the Zone Control Panels via an Ethernet network. Each Zone Control Panel shall be connected to the Vacuum Center Control Panel by its own, dedicated CAT5e or CAT6 cable without repeaters or switches.

b. The Vacuum Center Control Panel shall allow all operating parameters in the Zone Control Panels to be adjusted from its Operator Interface Terminal. Refer to Section 2.4 for a complete description of the control strategies and adjustable parameters required to be furnished.

PART 3 - EXECUTION

3.1 VACUUM PLUMBING SYSTEM - INSTALLATION

A. PROTECTION AND CLEANING

1. Vacuum Valve Equipment: Protect from weather, construction debris, damage, dust, mortar splatter, direct paint or paint splatter by covering with plastic sheeting or bags. Remove covering after construction is substantially complete but before system start up.

2. Pipe: Due to the nature of the system and the possibility of equipment damage, it is very important to protect the piping system from entry of foreign material and debris during installation. Any damage caused by foreign objects or materials in the piping are excluded from warranty coverage and shall be repaired by the Installing plumbing contractor under the general project warranty.

3. Fixtures and Valves: Protect from weather, construction debris, damage, dust, mortar splatter, direct paint or paint splatter by leaving factory provided protective covering and cardboard inserts in place during installation. Remove cardboard and coverings after construction is substantially complete but before system start up.
B. INSTALLATION-GENERAL: Installation shall be in strict accordance with the contract documents, Manufacturer's installation instructions, and with local authority approval. Provide service clearance for all system components in accord with manufacturers’ drawings and directions, and as necessary to facilitate maintenance and replacement. Minimum service clearance shall be 36” on all sides of the vacuum center equipment. Install valves in accessible locations or provide access doors or panels per contract documents in walls, partitions, floors or ceilings as indicated on plans.

C. PIPE INSTALLATION

1. Size and type, as shown on plans. Do not vary without written approval of the Engineer.
2. All pipe shall be cut clean and square and de-burred using abrasive saw method, or per manufacturer recommendation, taking care to leave no burrs on the inside of the piping.
3. Where employed, No Hub Cast Iron pipe shall be cut to length using an abrasive saw method. The use of adjustable chain type cutters is prohibited.
4. All fittings shall be approved for DWV usage.
5. Inside surfaces of vacuum drainage piping shall be smooth and free of burrs, weld bead protrusions and abrupt changes in cross section.
6. Taper ream all joints in which the inside diameter of the vacuum drainage pipe and fitting do not meet. Pipe/fitting interface shall produce a smooth transition.
7. All ninety-degree change of direction in the horizontal vacuum drainage piping shall be made up of long radius bends.
8. All 45-degree changes of direction in vacuum drainage piping shall be made with appropriate fittings bends.
9. Vacuum drainage piping shall maintain a positive slope with a minimum 1/4” per foot in the direction of flow.
10. Vacuum drainage piping shall be routed in an orderly fashion, with a minimum number of fittings, parallel and perpendicular to building lines unless otherwise indicated on drawings.
11. Installing plumbing contractor shall consider expansion and contraction during pipe installation to prevent excessive stress on pipe, fittings, or connected equipment.
12. Bracing:
   a. ALL piping shall be supported, braced and secured to resist thrusting forces exerted during vacuum system operation.
   b. Correct bracing is to be accomplished by use of multi-directional pipe clamps and rigid support assemblies.
   c. Proper bracing has been achieved when no noticeable movement of the vacuum piping occurs during operation.
   d. ALL piping shall be braced per manufacturer's or local code requirements, whichever is more restrictive.
   e. All bracing assemblies must be attached to a rigid base. Structural steel, rigid studs, or wooden backings shall be used to provide adequate support. Drywall, thin sheet metal and/or HVAC ductwork are not acceptable bases.
   f. Bracing of horizontal pipe should be in eight foot intervals, or as required by local code.
   g. Sagging of piping between supports is not permitted.
   h. Lateral or seismic bracing should be added every 25 feet when the hanger assembly is greater than 36” long.
   i. When a Uni-Strut or equivalent trapeze is used, piping shall be clamped down securely.
   j. Vertical lifts or risers are to be secured at so that no noticeable movement is of riser or lift piping during operation.
k. An approved bracing assembly shall be installed within one foot of every directional change on both sides of the fitting.
l. An approved bracing assembly shall be installed within one foot of every Extraction Valve, on both the inlet and outlet sides.
m. Connections to Equipment: Provide additional supports so that the equipment connections bear none of the piping weight or other forces.

13. Cleanouts: Located as follows:
   a. At intervals no greater than 70 feet.
   b. At the end of all vacuum mains, and at the end of each branch line, unless the branch line serves a single fixture that discharges into the main from above.
   c. So that no more than one 90-degree change in pipe direction occurs between cleanouts.
   d. At slope make ups.

14. Branch to Main and Riser to Branch Connections: Made with wye pattern fittings; and shall not be rolled more than 45 degrees from vertical.

15. Offsets:
   a. Maximum offset allowed in a vertical lift or riser (a single vacuum toilet or single accumulator with lift) shall be 12 inches, measured horizontally from the centerline of the pipe.
   b. Only one offset is allowed in a single vertical lift or riser and shall be made with two 1/8 bend fittings.
   c. The offset should be made as close as possible to the vacuum toilet or accumulator.

16. Maximum Lift Height – As per the drawings

17. Sensor ports: Fabricated from 1-1/2” pipe with an airtight cap and ¼” barbed fitting, connected to the valve controller.

18. Sensor port tubing:
   a. Bending Radius: Minimum 3” to prevent crimping. Crimps shall not be allowed in vacuum tubing; ensure there is no compression on sensor port tubing by any external support or clamping device or adjacent equipment across its entire length.
   b. Routing: Between the sensor port at the accumulator and on the valve controller so that there are no low areas or traps.
   c. Mini Check Valves: Manufacturer’s check valves shall be installed in vacuum source tubing to prevent migration of wastewater into the valve controller.

19. Valves
   a. Isolation Valves: Installed with stems above horizontal plane, not inverted.
   b. Check Valves: Installed horizontally and oriented so that flapper rests on seat under no-flow conditions.

20. Installing plumbing contractor shall consult with engineer for any deviation from the piping plans.

21. Installing plumbing contractor shall protect equipment drain lines from clogging, debris and damage for the duration of construction period by placing plugs in end of uncompleted work at the end of each workday or when work is stopped. Installing plumbing contractor shall protect valve components from paint, construction debris, and dust, at all times.

22. The Installing plumbing contractor shall be responsible for inter-connecting the equipment at the Vacuum Center, including waste and vacuum drainage piping and valves.
23. The Installing plumbing contractor shall coordinate electrical work with the Electrical Contractor required for power and control wiring. The Electrical Contractor shall wire remote monitoring alarms and indications from the dry sets of contacts to the Owner’s Building Controls Systems.

24. The Installing plumbing contractor shall coordinate with the manufacturer for installation inspection and on-site start-up of the system. The Manufacturer shall advise the Owner’s representative and Engineer that the vacuum drainage piping and collection system equipment have been installed as described in the project plans, specifications and Manufacturer’s installation instructions.

25. The Manufacturer will provide installation training for selected Installing plumbing contractor. Prior to commencing any fabrication of the vacuum piping system, the Installing plumbing contractor shall participate in an installation training program provided by the manufacturer. Participants from the Installing plumbing contractors’ organization who shall attend this mandatory training session include the contractors’ Project Manager and any individuals from their firm who will be directly involved in the installation work. In addition, a representative from the General Contractors office shall also attend to ensure that they are aware of the responsibilities being assumed by the Installing plumbing contractor, especially with respect to scheduling of site progress inspections.

D. VACUUM WASTE SYSTEM INSTALLATION INSPECTION

1. All vacuum waste system installation shall be inspected by the manufacturer or its representatives to insure proper operation of the system and maintain product warranty.

2. Scheduled inspection of piping and component installation by the manufacturer or its representatives shall take place at specific intervals of completion during the construction period. The manufacturer will provide up to six progress inspections at a rate of approximately once per month; inspection schedule to be determined by the Owner’s representative, Engineer, and Installing plumbing contractor prior to commencement of the installation. At the completion of each inspection, a formal written report of the findings, along with all supporting documentation necessary to convey issues and discrepancies that require corrective measures will be submitted to the Owners Representative, Engineer, General Contractor, and the Installing plumbing contractor. The manufacturer will provide additional, or more frequent, inspections when required. Charges for additional site and progress inspections shall be at additional cost for the Owner, or owner’s representative beforehand.

3. The manufacturer shall receive a written request for inspection no later than two weeks prior to the requested inspection date. All inspection requests shall include detailed information regarding the scope of work to be inspected.

4. All work scheduled for inspection shall be complete before inspection will take place. Any work that has been scheduled for inspection and is not complete at the time of inspection will require re-inspection and shall be subject to additional costs to the Owner and shall be approved by the Owner, or the owner’s representative beforehand.

5. A representative of the Installing plumbing contractor, General Contractor, and Owner’s representative shall be present and accompany the manufacturer’s representative at the time of inspection. All noted discrepancies shall be corrected before additional inspections can be scheduled. The manufacturer will not warranty the operation of the system or equipment if any portion of work has not been inspected, has been inspected but has not been corrected, or has not been installed in accordance with the contract documents and the manufacturer’s installation guidelines and recommendations.

E. VACUUM WASTE PIPE SYSTEM TESTING
1. Installing plumbing contractor shall test all vacuum piping for leaks and defects. Check the tightness of the vacuum piping during construction as sections are completed. Test vacuum piping before toilets, fixtures, etc. are installed. Block fixture connections with rubber plugs during testing.

2. The vacuum piping shall first be tested for leakage under positive pressure before any vacuum flush valves, extraction valves, vacuum check valves, vacuum toilets or vacuum tanks are connected to the piping. Do not subject the manufacturer furnished vacuum valves (check valves, flush valves, extraction valves) to positive pressure. A minimum pressure test of 30 psig is requested unless it exceeds the manufacturers recommendation and at that time the manufactures recommendation shall prevail.

3. After the positive pressure test has been passed, the vacuum piping shall then be tested for leakage under negative pressure. A pressure gauge shall be installed at visible location and shall not indicate any loss of pressure for a period not less than one hour. The area/section/system under test will be considered suitable for use when tested under a vacuum pressure of 22 inches Hg with a leak rate equal to, or less than, 6 inches Hg.

4. After the valves, toilets, tanks, etc. have been connected, the entire vacuum waste system shall be tested for leakage under negative pressure. The leak rate for this test shall not exceed 0.10 inches Hg, vacuum pressure per minute, or 6 Hg inches vacuum pressure Hg. per hour.

5. If the leakage rate is greater than that specified above in any of the test sequences, locate and repair all leaks and defects with new materials and retest system or portion thereof until satisfactory results are obtained. If testing is performed in segments, Installing plumbing contractor should submit a separate report for each test, complete with a diagram of the portion of the vacuum system tested.

F. VACUUM WASTE SYSTEM COMMISSIONING

1. Vacuum Center Equipment Pre-Startup Checks:
   a. The Installing plumbing contractor shall perform the following operations and checks prior to contacting the manufacturer for Vacuum Center Equipment Startup. Operations and checks need only be completed for equipment necessary for vacuum center equipment startup for typical test area (i.e., the whole vacuum system for the facility does not have to be complete and commissioned).
      1) Remove temporary end cap protectors.
      2) Verify that vacuum piping and electrical power have been connected to the Vacuum Center equipment.
      3) Verify valves, controllers, vacuum tubing, and vacuum center equipment have been installed per the manufacturer’s installation instructions and guidelines.
      4) Repair or replace damaged or defective equipment, specialties, and accessories.
      5) Verify service clearance has been provided for all equipment as required in drawings and specifications.
      6) Verify in writing that the system is complete and ready for inspection and start up.

2. Vacuum Center Equipment Pre-Startup Checks: By the Manufacturer after the Installing plumbing contractor performs pre-startup checks and certifies that the system is ready for startup.

3. Preparation for System Startup: After vacuum center equipment has been checked, started, and placed into operation, the Manufacturer shall demonstrate to the Installing plumbing contractor how to complete functional testing of the remainder of the system, including valve Controllers, Extraction Valves, fixtures, fixture controls, etc.
4. System Pre-Startup Checks
   a. The installing plumbing contractor shall perform the following operations and checks prior to contacting the Manufacturer for system startup.
      1) Remove plastic covers from controllers, extraction valves, and associated equipment.
      2) Perform functional test on all fixtures
         a) Check flush valve operation.
         b) Check rinse valve operation.
         c) Check extraction valve operation.
         d) Check bypass valve operation.
         e) Ensure that drains and piping are free of debris and not clogged.
         f) Ensure that hot and cold water to fixtures is turned on and functional.
      3) Perform leakage tests as described herein.
      4) Ensure that there are no traps in sensor lines.
      5) Ensure that vacuum tubing is not kinked, damaged, or otherwise blocked.
      6) Ensure the valves, controllers, vacuum tubing, and vacuum central equipment have been installed per the Manufacturer’s recommendations.
      7) Repair or replace damaged or defective equipment, specialties, and accessories.
      8) Verify service clearances have been provided for all equipment as required herein.
      9) Verify in writing that the system is complete and ready for inspection and startup by the Manufacturer.

5. All piping shall fully flushed and completely be clean and free of debris prior to installation of the vacuum components and water valves. Vacuum components and water valves supplied by the Manufacturer damaged by debris or chemical treatment processes in the piping network will not be warranted.

3.2 CLEANING AND FINISHING
   A. Upon completion of work in each respective area, clean and protect work. Just prior to final acceptance, perform additional cleaning as necessary to provide clean equipment and areas.
   B. Demonstrate system and instruct facility maintenance personnel in operation, repair, and maintenance of work of this section under provisions of Division 1, coincident with instruction period specified in other Division 22 sections.

3.3 CONNECTIONS
   A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.
   B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
   C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
3.4 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
   1. Waste collection tanks.
   2. Vacuum pumps.
   3. Waste ejection pumps.
   4. Grinder pumps.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:
   1. Test each vacuum center pump according to authorities having jurisdiction and the device’s reference standard.

B. Remove and replace malfunctioning vacuum waste piping specialties and retest as specified above.

C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

END OF SECTION 221424
SECTION 221430 - RAINWATER HARVESTING SYSTEM

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes the following rainwater harvesting system components:
      1. Rainwater pre-filters.
      2. Storage tanks.
      3. Distribution pumps.
      4. Controls.
      5. Secondary filters.
      6. Additional purification.
      7. Expansion tanks.
      8. Pressure switches.
   B. Related Sections include the following:
      1. Division 22 Section “Domestic Water Piping”.
      2. Division 22 Section “Sanitary, Clearwater Waste, Storm, and Vent Piping”.
      3. Division 22 Section “Storm Drainage Piping Specialties”.

1.2 REFERENCES
   A. American Society of Mechanical Engineers (ASME) - International Boiler and Pressure Vessel Code.
   B. Underwriters Laboratories, Inc. (UL) - Listed Products Directory.

1.3 SUBMITTALS
   A. Submittals for Review:
      1. Shop Drawings: Include system layout, components, wiring diagrams, and accessories.
      2. Product Data: Provide for system components; include dimensions, capacities, operating characteristics, utility connections, and accessories.
   B. Closeout Submittals:
      1. Operation and Maintenance Data: For rainwater harvesting system components to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE
   A. Electrical Components: Listed by UL.
   B. Above ground water storage tanks to be UL listed.

1.5 DELIVERY, STORAGE AND HANDLING
   A. Do not deliver system components until time needed for installation, and after proper protection can be provided.
   B. Protect components from damage and corrosion.
   C. Leave protective coverings in place until just prior to installation.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: Per the manufacturer listed

B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

2.2 STORAGE TANKS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ACF Environmental.
   2. Containment Solutions, Inc., Conroe, TX.
   4. Xerxes.

B. Polyethylene Storage Tank:
   1. Polyethylene, produced with 100 percent virgin resin meeting FDA specifications for potable water storage.
   2. Storage capacity: [_____] gallons.
   3. Manhole extensions and lid/riser combinations for access at ground level.
   4. Ventilation: To suit project conditions.

C. PVC Lined Storage Tank:
   1. Modular tank system with PVC liner, designed to specific project requirements.
   2. Penetrations and pump connections designed into tank configuration.
   4. Manhole extensions and lid/riser combinations for access at ground level.
   5. Ventilation: To suit project conditions.

D. Fiberglass Storage Tank:
   1. Fiberglass, molded to specific project requirements.
   2. Penetrations molded into tank.
   4. Manhole extensions and lid/riser combinations for access at ground level.
   5. Ventilation: To suit project conditions.

E. Polyethylene Storage Tank:
   1. Polyethylene, produced with resins meeting FDA specifications for potable water storage.
   2. Black or dark green color.
   4. Manhole lid.
   5. Ventilation: To suit project conditions.

2.3 PUMPS AND PUMP SKIDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Grundfus.
B. Pumps and Pump Skids:
   1. Pump capacity: [____] gallons per minute at [____] PSI.
   2. Submersible pumps: Manufactured specifically for submersible operation.
   4. Plumbed to allow for removal without entering tank.
   5. Connected to power supply by power cable and waterproof connections.
   6. Furnish with pump the MAGNA3 communication equipment and motors with electronic speed control.

2.4 CONTROLS AND FLOAT SWITCHES
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Control Systems, Inc.
   2. Flowline.
B. Control Panel:
   1. Housed in NEMA 4 hinged wall mount enclosure with back plate, fully integrated into rainwater harvesting system, prefabricated and configured to run pumps as required.
   2. Provide one normally open float switch to protect pump from run dry condition.
   3. Provide one normally closed float switch to activate normally closed solenoid valve to activate make-up water source.

2.5 RAINWATER FILTERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
B. Inline Downspout Rainwater Filter:
   1. Description: Downspout conversion kit, stainless steel filter, and 280 micron stainless steel fine mesh filter.
C. Standpipe Downspout Rainwater Filter:
   1. Description: Downspout conversion kit, stainless steel filter, and 280 micron stainless steel fine mesh filter.

2.6 STORAGE TANK ACCESSORIES
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
B. Storage Tank Accessories:
   1. Smoothing inlets:
      a. Description: Stainless steel smoothing inlet for a [enter size] inch inlet pipe.
2. Floating filter and hose:
   a. Description: Stainless steel filter housing and mesh fabric, and polyethylene floating ball.

3. Overflow device:
   a. Description: Impact-resistant ABS plastic overflow device with support strut and clamp for 4 inch overflow piping.

4. Level indicator:
   a. Description: Wireless storage tank level sensor.

5. Float switch:
   a. Description: Polyethylene switch level and float housing with flexible cable; dry run protection, normally open.

6. Second source storage tank float switch:
   a. Description: Polyethylene switch level and float housing with flexible cable; control normally closed solenoid valve.

2.7 LIMESTONE SYSTEM
   A. Manufacturers:

2.8 EXPANSION TANKS AND PRESSURE SWITCHES
   A. Expansion Tanks:
      1. Pressure tank: Sized to system requirements and to meet or exceed manufacturer's specifications; minimum flow rate of 3 x pump system.

   B. Pressure Switches:
      1. Pressure switch, gauge, boiler drain, and brass nipple.

2.9 ACCESSORIES
   A. Bulkhead fittings, sized to match system inlet, outlet, pump flow rate, vents, and other penetrations.
   B. Vent assembly: PVC rodent-proof cap for tank air and vacuum relief; extend from top of tank to above grade.
   C. Waterproof electrical connection box: Located in manway, field installed.

2.10 SOURCE QUALITY CONTROL
   A. Assemble and test purification system in factory prior to shipment to Project site.
   B. Hydrostatically test prefabricated pump assembly in factory prior to shipment to Project site.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Refer to Division 22 Section “Basic Division 22 Requirements” for piping joining materials, joint construction, and basic installation requirements.

RAINWATER HARVESTING SYSTEM
B. Install system components in accordance with manufacturer's instructions and approved Shop Drawings.

C. Arrange equipment so that components requiring removal or maintenance are readily accessible without disturbing other components. Arrange for clear passage between components.

D. Connect to utility supplies and equipment.

E. Ground components in accordance with component manufacturer's instructions.

F. Provide documentation for submission to USGBC

3.2 CONNECTIONS
A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and system components.

3.3 PROTECTION
A. Place plugs in openings of uncompleted system components at end of each day or when work stops.

3.4 FIELD QUALITY CONTROL
A. Provide startup services to include:
   1. Installation oversight and technical support.
   2. Terminate and test control system wiring and operation of electrical components.
   3. Demonstrate proper pump and controls operation.
   4. Make adjustments to meet user-defined system performance.
   5. Review operation and maintenance procedures with Owner's representative.

END OF SECTION 221430
SECTION 221513 - GENERAL-SERVICE COMPRESSED-AIR PIPING

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes piping and related specialties for general-service compressed-air systems operating at 150 psig or less.
   B. Related Sections include the following:
      1. Division 22 Section "General-Service Packaged Air Compressors and Receivers" for general-service air compressors and accessories.

1.2 DEFINITIONS
   B. CR: Chlorosulfonated polyethylene synthetic rubber.
   C. EPDM: Ethylene-propylene-diene terpolymer rubber.
   D. HDPE: High-density polyethylene plastic.
   E. NBR: Acrylonitrile-butadiene rubber.
   F. PE: Polyethylene plastic.
   G. PVC: Polyvinyl chloride plastic.
   H. Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures of 150 psig or less.

1.3 SUBMITTALS
   A. Product Data: For the following:
      1. Dielectric fittings.
      2. Flexible pipe connectors.
      4. Pressure regulators. Include rated capacities and operating characteristics.
      5. Automatic drain valves.
      6. Filters. Include rated capacities and operating characteristics.
      7. Lubricators. Include rated capacities and operating characteristics.
      8. Quick couplings.
      9. Hose assemblies.
   B. Field quality-control test reports.
   C. Operation and Maintenance Data: For general-service compressed-air piping specialties to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE
   A. Installer Qualifications:
      1. Extruded-Tee Outlet Procedure: Qualify operators according to training provided by T-DRILL Industries Inc., for making branch outlets.
      2. Pressure-Seal Joining Procedure for Copper Tubing: Qualify operators according to training provided by Viega; Plumbing and Heating Systems.
3. Pressure-Seal Joining Procedure for Steel Piping. Qualify operators according to training provided by Victaulic Company.

B. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or to AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

D. ASME Compliance:

1.5 PROJECT CONDITIONS
A. Interruption of Existing Compressed-Air Service: Do not interrupt compressed-air service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary compressed-air service according to requirements indicated:
   1. Notify Construction Manager and Owner no fewer than two days in advance of proposed interruption of compressed-air service.
   2. Do not proceed with interruption of compressed-air service without Owner's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Basis of Design: Per the manufacturer listed.
B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

2.2 PIPES, TUBES, AND FITTINGS
A. Copper Tube: ASTM B 88, Type K or L seamless, drawn-temper, water tube.
   1. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, wrought copper with dimensions for brazed joints.
   2. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150 or 300.
   3. Copper Unions: ASME B16.22 or MSS SP-123.
   4. Press-Type Fittings, NPS 2 and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Viega; Plumbing and Heating Systems.
   5. Press-Type Fittings, NPS 2-1/2 to NPS 4: Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) Viega; Plumbing and Heating Systems.

B. Transition Couplings for Metal Piping: Metal coupling or other manufactured fitting same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for compressed-air piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated.

E. Copper Press-Connect Fittings: ASTM B 16.24 class 150 powder coated steel plate two piece design for potable water. Housing is copper or bronze with EPDM housing sealing element with manufacturer special tool with maximum 200 psig working pressure rated at 250° F.

2.4 VALVES

A. Metal Ball, Butterfly, Check, and Gate Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping."

2.5 DIELECTRIC FITTINGS

A. General Requirements for Dielectric Fittings: Combination fitting of copper alloy and ferrous materials with insulating material; suitable for system fluid, pressure, and temperature. Include threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Dielectric Unions: Factory-fabricated union assembly, for 250-psig minimum working pressure at 180° F.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Central Plastics Company.
      c. EPCO Sales, Inc.
      d. Hart Industries International, Inc.
      e. Watts Water Technologies, Inc.; Water Products Div.
      f. Zurn Plumbing Products Group; Wilkins Div.
      g. Nibco Viega LLC.

C. Dielectric Flanges: Factory-fabricated companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
b. Central Plastics Company.
c. EPCO Sales, Inc.

D. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.

E. Dielectric Union with Press-Connection Fittings:

1. For types K, L and M: hard copper tubing in 1/2" to 2" sizes
2. Galvanized metal female NPT threaded connection.
3. Gasket: EDPM.
4. Electrical conductivity separation ring.
5. Bronze: propress connection with smart connect feature.
6. Sealing element: EDPM.
7. Sealed with Manufacturers special tool.

2.6 FLEXIBLE PIPE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Flex-Hose Co., Inc.
2. Flexicraft Industries.
3. Hyspan Precision Products, Inc.
5. Metraflex, Inc.
6. Proco Products, Inc.
7. Unaflex, Inc.
8. Universal Metal Hose; a Hyspan Company

B. Bronze-Hose Flexible Pipe Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

2. End Connections, NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections, NPS 2-1/2 and Larger: Flanged copper alloy.

C. Stainless-Steel-Hose Flexible Pipe Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

2. End Connections, NPS 2 and Smaller: Threaded steel pipe nipple.
3. End Connections, NPS 2-1/2 and Larger: Flanged steel nipple.
2.7 SPECIALTIES

A. Safety Valves: ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," construction; National Board certified, labeled, and factory sealed; constructed of bronze body with poppet-type safety valve for compressed-air service.
   1. Pressure Settings: Higher than discharge pressure and same or lower than receiver pressure rating.

B. Air-Main Pressure Regulators: Bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 250-psig inlet pressure, unless otherwise indicated.
   1. Type: Pilot operated.

C. Air-Line Pressure Regulators: Diaphragm operated, bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 200-psig minimum inlet pressure, unless otherwise indicated.

D. Air-Line Pressure Regulators: Diaphragm operated, aluminum alloy or plastic body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 200-psig minimum inlet pressure, unless otherwise indicated.

E. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig minimum working pressure, capable of automatic discharge of collected condensate. Include mounting bracket if wall mounting is indicated.

F. Coalescing Filters: Coalescing type with activated carbon capable of removing water and oil aerosols; with color-change dye to indicate when carbon is saturated and / or warning light to indicate when selected maximum pressure drop has been exceeded. Include mounting bracket if wall mounting is indicated. Signal to be sent to the Building Automation System.

G. Mechanical Filters: Two-stage, mechanical-separation-type, air-line filters. Equip with deflector plates, resin-impregnated-ribbon-type filters with edge filtration, and drain cock. Include mounting bracket if wall mounting is indicated.

H. Air-Line Lubricators: With drip chamber and sight dome for observing oil drop entering air stream; with oil-feed adjustment screw and quick-release collar for easy bowl removal. Include mounting bracket if wall mounting is indicated.
   1. Provide with automatic feed device for supplying oil to lubricator.

2.8 QUICK COUPLINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Aeroquip Corporation; Eaton Corp.
   2. Bowes Manufacturing Inc.
   3. Foster Manufacturing, Inc.
   5. Parker Hannifin Corp.; Fluid Connectors Group; Quick Coupling Div.
   6. Rectus Corp.
   7. Schrader-Bridgeport; Amflo Div.
   9. Snap-Tite, Inc.; Quick Disconnect & Valve Division.
   10. TOMCO Products Inc.
   11. Tuthill Corporation; Hansen Coupling Div.
B. General Requirements for Quick Couplings: Assembly with locking-mechanism feature for quick connection and disconnection of compressed-air hose.

C. Automatic-Shutoff Quick Couplings: Straight-through brass body with O-ring or gasket seal and stainless-steel or nickel-plated-steel operating parts.
   1. Socket End: With one-way valve and threaded inlet for connection to piping or threaded hose fitting.
   2. Plug End: [Flow-sensor-bleeder, check-valve] [Straight-through] type with barbed outlet for attaching hose.

D. Valveless Quick Couplings: Straight-through brass body with stainless-steel or nickel-plated-steel operating parts.
   1. Socket End: With O-ring or gasket seal, without valve, and with barbed inlet for attaching hose.
   2. Plug End: With barbed outlet for attaching hose.

2.9 HOSE ASSEMBLIES
A. Description: Compatible hose, clamps, couplings, and splicers suitable for compressed-air service, of nominal diameter indicated, and rated for 300-psig minimum working pressure, unless otherwise indicated.
   1. Hose: Reinforced [single] [single- or double] [double]-wire-braid, CR-covered hose for compressed-air service.
   2. Hose Clamps: Stainless-steel clamps or bands.
   3. Hose Couplings: Two-piece, straight-through, threaded brass or stainless-steel O-ring or gasket-seal swivel coupling with barbed ends for connecting two sections of hose.
   4. Hose Splicers: One-piece, straight-through brass or stainless-steel fitting with barbed ends for connecting two sections of hose.

2.10 GROUT
A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION
3.1 PIPING APPLICATIONS
A. Low-Pressure Compressed-Air Distribution Piping: Use the following piping materials for each size range:
   1. NPS 1 and Smaller: Type L, copper tube; wrought-copper fittings; and brazed joints, above ground, within building.
   2. NPS 2 and Smaller: Type L, copper tube; press-type fittings; and pressure-sealed joints.
   3. NPS 2-1/2 to NPS 4: Type L, copper tube; wrought-copper fittings; and brazed [or soldered] joints.
   4. NPS 2-1/2 to NPS 4: Type L, copper tube; press-type fittings; and pressure-sealed joints.

B. Drain Piping: Use the following piping materials:
1. NPS 2 and Smaller: Type L copper tube; wrought-copper fittings; and brazed or soldered joints.

3.2 VALVE APPLICATIONS

A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for metal general-duty valves. Use metal valves, unless otherwise indicated.

1. Metal General-Duty Valves: Use valve types specified in "Valve Applications" Article in Division 22 Section "General-Duty Valves for Plumbing Piping" according to the following:
   a. Low-Pressure Compressed Air: Valve types specified for low-pressure compressed air.
   b. High-Pressure Compressed Air: Valve types specified for medium-pressure compressed air.
   c. Equipment Isolation NPS 2 and Smaller: Safety-exhaust, copper-alloy ball valve with exhaust vent and pressure rating at least as great as piping system operating pressure.
   d. Grooved-end valves may be used with grooved-end piping and grooved joints.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping concealed from view and protected from physical contact by building occupants, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited, unless otherwise indicated.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and to coordinate with other services occupying that space.

E. Install piping adjacent to equipment and machines to allow service and maintenance.

F. Install air and drain piping with 1 percent slope downward in direction of flow.

G. Install nipples, flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating, unless otherwise indicated.

H. Equipment and Specialty Flanged Connections:
   1. Use steel companion flange with gasket for connection to steel pipe.
   2. Use cast-copper-alloy companion flange with gasket and brazed [or soldered] joint for connection to copper tube. Do not use soldered joints for connection to air compressors or to equipment or machines producing shock or vibration.

I. Flanged joints may be used instead of specified joint for any piping or tubing system.

J. Extended-tee outlets with brazed branch connection may be used for copper tubing, within extruded-tee connection diameter to run tube diameter ratio for tube type, according to Extruded Tee Connections Sizes and Wall Thickness for Copper Tube (Inches) Table in ASTM F 2014.

K. Install eccentric reducers where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
L. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.

M. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping."

N. Install piping to permit valve servicing.

O. Install piping free of sags and bends.

P. Install fittings for changes in direction and branch connections.

Q. Install sleeves for piping penetrations of walls, ceilings and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

S. Install escutcheons for piping penetrations of walls, ceiling and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.4 JOIN CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints for Steel Piping: Join according to AWS D10.12/D10.12M.

E. Brazed Joints for Copper Tubing: Join according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Join according to ASTM B 828 or CDA's "Copper Tube Handbook."

G. Extruded-Tee Outlets for Copper Tubing: Form branches according to ASTM F 2014, with tools recommended by procedure manufacturer, and using operators qualified according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Use asbestos-free, nonmetallic gasket suitable for compressed air. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.

I. Pressure-Sealed Joints: Join with tools recommended by fitting manufacturer, using operators qualified according to Part 1 "Quality Assurance" Article.

J. Dissimilar Metal Piping Material Joints: Use dielectric fittings.
3.5 VALVE INSTALLATION
   A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping."
   B. Install shutoff valves and unions or flanged joints at compressed-air piping to air compressors.
   C. Install shutoff valve at inlet to each automatic drain valve, filter, lubricator, and pressure regulator.
   D. Install check valves to maintain correct direction of compressed-air flow to and from compressed-air piping specialties and equipment.

3.6 DIELECTRIC FITTING INSTALLATION
   A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
   B. NPS 2 and Smaller: Use dielectric unions.
   C. NPS 2-1/2 to NPS 4: Use dielectric flanges.

3.7 FLEXIBLE PIPE CONNECTOR INSTALLATION
   A. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter of each air compressor.
   B. Install bronze-hose flexible pipe connectors in copper compressed-air tubing.
   C. Install stainless-steel-hose flexible pipe connectors in steel compressed-air piping.

3.8 SPECIALTY INSTALLATION
   A. Install safety valves on receivers in quantity and size to relieve at least the capacity of connected air compressors.
   B. Install air-main pressure regulators in compressed-air piping at or near air compressors.
   C. Install air-line pressure regulators in branch piping to equipment and tools.
   D. Install automatic drain valves on aftercoolers, receivers, and dryers. Discharge condensate onto nearest floor drain.
   E. Install coalescing filters in compressed-air piping at or near air compressors and upstream from mechanical filters. Mount on wall at locations indicated.
      1. Alarm signal to be sent to the Building Automation System.
   F. Install mechanical filters in compressed-air piping at or near air compressors and downstream from coalescing filters. Mount on wall at locations indicated.
      1. Alarm signal to be sent to the Building Automation System.
   G. Install air-line lubricators in branch piping to machine tools. Mount on wall at locations indicated.
   H. Install quick couplings at piping terminals for hose connections.
   I. Install hose assemblies at hose connections.
3.9 CONNECTIONS
A. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment and machine.
B. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment and machine.

3.10 HANGER AND SUPPORT INSTALLATION
A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.
B. Vertical Piping: MSS Type 8 or 42, clamps.
C. Individual, Straight, Horizontal Piping Runs:
   1. 100 Feet or Less: MSS Type 1, adjustable, steel clevis hangers.
   2. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
D. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
E. Base of Vertical Piping: MSS Type 52, spring hangers.
F. Support horizontal piping within 12 inches of each fitting and coupling.
G. Install hangers for Schedule 40, steel piping with the following maximum horizontal spacing and minimum rod diameters per Section 220529 “Hangers and Supports.”
H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters per Section 220529 “Hangers and Supports.”

3.11 LABELING AND IDENTIFICATION
A. Install identifying labels and devices for general-service compressed-air piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.12 FIELD QUALITY CONTROL
A. Perform field tests and inspections.
B. Tests and Inspections:
   1. Piping Leak Tests for Metal Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen to pressure of 50 psig above system operating pressure, but not less than 150 psig. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
   2. Repair leaks and retest until no leaks exist.
   3. Inspect filters and pressure regulators for proper operation.
C. Prepare test reports.

END OF SECTION 221513
SECTION 221519 - GENERAL-SERVICE PACKAGED AIR COMPRESSORS AND RECEIVERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Oil-free, reciprocating air compressors.
   2. Oil-free, rotary-screw air compressors.
   3. Inlet-air filters.
   4. Air-cooled, compressed-air aftercoolers.
   5. Refrigerated compressed air dryers.
   6. Desiccant compressed-air dryers.

1.2 DEFINITIONS

A. Actual Air: Air delivered from air compressors. Flow rate is delivered compressed air measured in acfm (actual cf/m).

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

C. Standard Air: Free air at 68 °F and one (1) atmosphere (29.92 in. Hg) before compression or expansion and measured in scfm (standard L/s).

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design compressed-air equipment mounting, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   1. Wiring Diagrams: For power, signal, and control wiring.

B. Delegated-Design Submittal: For compressed-air equipment mounting indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail fabrication and assembly of supports.

C. Operation and Maintenance Data: For compressed-air equipment to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label receivers to comply with ASME Boiler and Pressure Vessel Code.
1.6 PROJECT CONDITIONS
   A. Interruption of Existing Compressed-Air Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
      1. Notify Architect, Construction Manager and Owner no fewer than seven days in advance of proposed interruption of compressed-air service.
      2. Do not proceed with interruption of compressed-air service without Architect's, Construction Manager's and Owner's written permission.

1.7 COORDINATION
   A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.8 EXTRA MATERIALS
   A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      1. Air-Compressor, Inlet-Air-Filter Elements: Equal to 100 percent of amount installed units.
      2. Belts: One for each belt-driven compressor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Basis of Design: Per the manufacturer listed.
   B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

2.2 GENERAL REQUIREMENTS FOR PACKAGED AIR COMPRESSORS AND RECEIVERS
   A. General Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.
   B. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
      1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
      3. Control Voltage: 120-V ac or less, using integral control power transformer.
      5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
      6. Automatic control switches to sequence lead-lag compressors for multiplex air compressors.
      7. Instrumentation: Include discharge-air pressure gage, air-filter maintenance indicator, hour meter, compressor discharge-air and coolant temperature gages, and control transformer.
      8. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.
C. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   1. Pressure Rating: At least as high as highest discharge pressure of connected compressors, and bearing appropriate code symbols.
   2. Interior Finish: Corrosion-resistant coating.
   3. Accessories: Include safety valve, pressure gage, drain, and pressure-reducing valve.

D. Mounting Frame: Fabricate mounting and attachment to pressure vessel with reinforcement strong enough to resist packaged equipment movement during a seismic event when base is anchored to building structure.

2.3 OIL-FREE, RECIPROCATING AIR COMPRESSORS

A. Manufacturers: Verify that products of listed manufacturers can produce volume of air at pressure required.
   1. Gast Manufacturing Inc.
   2. Ingersoll-Rand; Air Solutions Group.
   3. Quincy Compressor; an EnPro Industries company.

B. Compressor(s): Oil-free, reciprocating-piston type with nonlubricated compression chamber, lubricated crankcase, and of construction that prohibits oil from entering compression chamber. This type of compressor systems shall be utilized for 2HP and smaller units or when specifically identified for a project.
   1. Submerged gear-type oil pump.
   2. Oil filter.
   3. Combined high discharge-air temperature and low lubrication-oil pressure switch.
   4. Belt guard totally enclosing pulleys and belts.

C. Capacities and Characteristics:
   1. Air Compressor(s): Refer to drawing schedule
   2. Standard-Air Capacity of Each Air Compressor: <Insert scfm> free air.
   3. Actual-Air Capacity of Each Air Compressor: <Insert acfm> delivered.
   4. Discharge-Air Pressure: [100 psig] [125 psig] Intake-Air Temperature: <Insert ° F >.
   5. Discharge-Air Temperature: <Insert ° F >.
   6. Mounting: identify that the unit is Freestanding or Tank mounted.
   7. Motor (Each Air Compressor):
      a. Horsepower: <Insert value>.
      b. Speed: [1750] [3400] <Insert speed> rpm.
   8. Unit Electrical Characteristics:
      a. Volts: <Insert value>.
      b. Phase(s): [Single] [Three].
      c. Hertz: 60 Hz.
      d. Full-Load Amperes: <Insert value>.
      e. Minimum Circuit Ampacity: <Insert value>.
      f. Maximum Overcurrent Protection: <Insert amperage>.
      a. Arrangement: Indicate that the orientation of the receiver is Horizontal or Vertical.
      b. Capacity: <Insert gal.>.
      c. Interior Finish: Epoxy > coating.
d. Pressure Rating: [100 psig] [125 psig] [150 psig] [200 psig] [250 psig] <Insert value> minimum.

e. Pressure Regulator Setting: <Insert psig >.

f. Pressure Relief Valve Setting: <Insert psig >.


2.4 OIL-FREE, ROTARY-SCREW AIR COMPRESSORS

A. Manufacturers: Verify that products of listed manufacturers can produce volume of air at pressure required.
2. CompAir, Ltd.
4. Ingersoll-Rand; Air Solutions Group.

B. Compressor(s): Oil-free, rotary-screw type with nonlubricated helical screws and lubricated gear box, and of construction that prohibits oil from entering compression chamber.
2. Cooling/Lubrication System: Unit-mounted, air-cooled exchanger package pre-piped to unit; with air pressure circulation system with coolant stop valve, full-flow coolant filter, and thermal bypass valve.
3. Air Filter: Dry type, with maintenance indicator and cleanable replaceable filter element.
5. Capacity Control: Capacity modulation between zero and 100 percent air delivery, with operating pressures between 50 and 100 psig (345 and 690 kPa). Include necessary control to hold constant pressure. When air demand is zero, unload compressor by using pressure switch and blowdown valve.

C. Capacities and Characteristics:
1. Air Compressor(s): Multiplex, single stage.
2. Standard-Air Capacity of Each Air Compressor: <Insert scfm > free air.
3. Actual-Air Capacity of Each Air Compressor: <Insert acfm > delivered.
4. Discharge-Air Pressure: [100 psig] [125 psig]
5. Intake-Air Temperature: <Insert °F >.
7. Motor (Each Air Compressor):
   a. Horsepower: <Insert value>.
   b. Speed: [1750] [3400] <Insert speed> rpm.

8. Unit Electrical Characteristics:
   a. Volts: <Insert value>.
   b. Phase(s): [Single] [Three].
   c. Hertz: 60 Hz.
   d. Full-Load Amperes: <Insert value>.
   e. Minimum Circuit Ampacity: <Insert value>.
   f. Maximum Overcurrent Protection: <Insert amperage>.

a. Arrangement: Indicate the orientation of the receiver as Horizontal or Vertical.
b. Capacity: \(<\text{Insert gal.}>\).
c. Interior Finish: Epoxy > coating.
d. Pressure Rating: 150 psig > minimum.
e. Pressure Regulator Setting: \(<\text{Insert psig}>\).
f. Pressure Relief Valve Setting: \(<\text{Insert psig}>\).

10. Enclosure: Steel with sound-attenuating material lining.

2.5 INLET-AIR FILTERS

A. Description: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.
   1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
   2. Capacity: Match capacity of air compressor, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.

B. Description: Combination inlet-air filter-silencer, suitable for remote installation, for multiple air compressors.
   1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
   2. Capacity: Match total capacity of connected air compressors, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.

2.6 AIR-COOLED, COMPRESSED-AIR AFTERCOOLERS

A. Manufacturers:
   1. Air/Tak, Inc.
   2. Arrow Pneumatics, Inc.
   3. Curtis-Toledo.
   5. Hankison International.
   6. Ingersoll-Rand; Air Solutions Group.
   7. Pneumatech Inc.
   9. Van Air Systems, Inc.
   10. Zeks Compressed Air Solutions.

B. Description: Electric-motor-driven, fan-operation, finned-tube unit; rated at 250 psig and leak tested at 350-psig minimum air pressure; in capacities indicated. Size units to cool compressed air in compressor-rated capacities to \([10^\circ \text{ F}] \ <\text{Insert temperature}>\) above summertime maximum ambient temperature. Include moisture separator and automatic drain.

C. Capacities and Characteristics:
   1. Standard-Air Capacity of Each Aftercooler: \(<\text{Insert scfm}>\) free air.
   2. Pressure: \(<\text{Insert psig}>\).
   3. Entering, Compressed-Air Temperature: \(<\text{Insert }^\circ \text{ F}>\).
   4. Leaing, Compressed-Air Temperature: \(<\text{Insert }^\circ \text{ F}>\).
   5. Ambient-Air Temperature: \(<\text{Insert }^\circ \text{ F}>\).
   6. Maximum Compressed-Air-Pressure Drop: \(<\text{Insert psig}>\).
   7. Motor Horsepower: \(<\text{Insert value}>\).

GENERAL SERVICE PACKAGED AIR COMPRESSORS AND RECEIVERS 221519 - 5

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8. Electrical Characteristics:
   a. Volts: `<Insert value>`.
   b. Phase(s): [Single] [Three].
   c. Hertz: 60 Hz.
   d. Full-Load Amperes: `<Insert value>`.
   e. Minimum Circuit Ampacity: `<Insert value>`.
   f. Maximum Overcurrent Protection: `<Insert amperage>`.

2.7 WATER-COOLLED, COMPRESSED-AIR AFTERCOOLERS

A. Manufacturers:
   1. Air/Tak, Inc.
   2. Arrow Pneumatics, Inc.
   3. Curtis-Toledo.
   5. Hankison International.
   6. Ingersoll-Rand; Air Solutions Group.
   7. Pneumatech Inc.
   9. Van Air Systems, Inc.
   10. Zeks Compressed Air Solutions.

B. Description: Shell and tube unit, rated at [250 psig] `<Insert pressure>` and leak tested at 350-psig (2415-kPa) minimum air pressure, in capacities indicated. Include moisture separator and automatic drain.

C. Capacities and Characteristics:
   2. Pressure: `<Insert psig >.

2.8 REFRIGERATED COMPRESSED AIR DRYERS

A. Manufacturers:
   1. Hankison International
   2. Ingersol Rand, Air Solutions Group
   3. Kaeser Compressors
   4. Zeks Compressed Air Solutions

B. Description: The refrigerated compressed air dryers, lowering the air temperature to 39°F, which causes the condensation of entrained moisture. The moisture is then directed to the specially designed moisture separator, where all liquids are removed. The cold, dry compressed air then returns through the first-stage heat exchanger for reheating by the incoming warm air.

C. Capacities and Characteristics:
   2. Pressure: `<Insert psig >.
5. Leaving-Air Dew Point Temperature: \(<\text{Insert ° F}>\).
6. Ambient-Air Temperature: \(<\text{Insert ° F}>\).
7. Maximum Air-Pressure Drop: \(<\text{Insert psig}>\).
8. Inlet Filter: 5 micron
9. Outlet Filter: 1 micron
10. Electrical Characteristics:
    a. Volts: \(<\text{Insert value}>\).
    b. Phase(s): \([\text{Single}] [\text{Three}]\).
    c. Hertz: \([60] <\text{Insert value}>\) Hz.
    d. Full-Load Amperes: \(<\text{Insert value}>\).
    e. Minimum Circuit Ampacity: \(<\text{Insert value}>\).

2.9 DESICCANT COMPRESSED-AIR DRYERS

A. Manufacturers:
1. Air/Tak, Inc.
2. Domnick Hunter Limited; ZANDER, Inc.
5. Ingersoll-Rand; Air Solutions Group.
6. Kaeser Compressors, Inc.
9. Pneumatech Inc.
10. SPX Air Treatment.
11. Van Air Systems, Inc.
12. Wilkerson Operations; Pneumatic Division.

B. Description: Twin-tower unit with purge system, mufflers, and capability to deliver plus 10 ° F, 100-psig air at dew point. Include dew point controlled purge, step-down transformers, disconnect switches, inlet and outlet pressure gages, thermometers, automatic controls, and filters.

C. Capacities and Characteristics:
1. Standard-Air Capacity of Each Compressed-Air Dryer: \(<\text{Insert scfm}>\) free air.
2. Pressure: \(<\text{Insert psig}>\).
3. Entering-Air Temperature: \(<\text{Insert ° F}>\).
4. Leaving-Air Temperature: \(<\text{Insert ° F}>\).
5. Leaving-Air Dew Point Temperature: \(<\text{Insert ° F}>\).
6. Ambient-Air Temperature: \(<\text{Insert ° F}>\).
7. Maximum Air-Pressure Drop: \(<\text{Insert psig}>\).
8. Inlet Filter: 5 microns.
9. Outlet Filter: 1 microns
10. Electrical Characteristics:
    a. Volts: \(<\text{Insert value}>\).
    b. Phase(s): \([\text{Single}] [\text{Three}]\).
    c. Hertz: \([60] <\text{Insert value}>\) Hz.
    d. Full-Load Amperes: \(<\text{Insert value}>\).
    e. Minimum Circuit Ampacity: \(<\text{Insert value}>\).
    f. Maximum Overcurrent Protection: \(<\text{Insert amperage}>\).
2.10 COMPUTER INTERFACE CABINET AND BUILDING AUTOMATION SYSTEM.

A. Description:
1. Wall mounting.
2. Welded steel with white enamel finish.
3. Gasketed door.
4. Grounding device.
5. Factory-installed, signal circuit boards.
7. Circuit breaker.
8. Wiring terminal board.

2.11 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 22 Section "Common Motor Requirements for Plumbing Equipment."
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Equipment Mounting: Install air compressors and required air treatment on concrete bases using elastomeric mounts Comply with requirements in Division 03 Section "Cast-in-Place Concrete " Comply with requirements for vibration isolation devices specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."
1. Minimum Deflection: [1/4 inch] [1 inch]
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Install compressed-air equipment anchored to substrate.

C. Arrange equipment so controls and devices are accessible for servicing.

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Install the following devices on compressed-air equipment:
1. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
2. Pressure Regulators: Install downstream from air compressors and dryers.
3. Automatic Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.
3.2 CONNECTIONS
A. Comply with requirements for piping specified in Division 22 Section "General-Service Compressed-Air Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to machine to allow service and maintenance.

3.3 IDENTIFICATION
A. Identify general-service air compressors and components. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.4 STARTUP SERVICE
A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checklist according to manufacturer's written instructions.
   2. Check for lubricating oil in lubricated-type equipment.
   3. Check belt drives for proper tension.
   4. Verify that air-compressor inlet filters and piping are clear.
   5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
   6. Check safety valves for correct settings. Ensure that settings are higher than air-compressor discharge pressure but not higher than rating of system components.
   7. Check for proper seismic restraints.
   8. Drain receiver tanks.
   9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   10. Test and adjust controls and safeties.

3.5 DEMONSTRATION
A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air compressors systems.

END OF SECTION 221519
SECTION 223100 - DOMESTIC WATER SOFTENERS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes commercial water softeners.
   1. Chemicals.
   2. Water testing kits.
B. Related Sections: The following sections contain requirements that relate to this Section:
   1. Division 23 Section "Basic Mechanical Requirements."
   2. Division 23 Section "Basic Mechanical Materials and Methods."

1.2 DEFINITIONS
B. FRP: Fiberglass-reinforced plastic.
C. PE: Polyethylene plastic.
D. PVC: Polyvinyl chloride plastic.

1.3 SUBMITTALS
A. Product Data: For the following:
   1. Refer to Division 23 Section "Basic Mechanical Requirements."
   2. Water Softeners. Include rated capacities, operating characteristics, furnished specialties, accessories and weights (shipping, installed and operating).
   3. Water testing kits.
B. Shop Drawings: For water softeners. Include plans, elevations, sections, details, and connections to piping systems.
C. Manufacturer Certificates: Signed by manufacturers certifying that water softeners comply with requirements.
D. Source quality-control test reports.
E. Field quality-control test reports.
F. Operation and Maintenance Data: For water softeners to include in emergency, operation, and maintenance manuals.
G. Warranty: Special warranty specified in this Section.
H. Agreement to Maintain: Prior to Substantial Completion, submit 4 copies of Manufacturer's "Agreement for Continued Service and Maintenance" for water softener, for Owner's acceptance. Offer terms and conditions for furnishing chemicals and providing continued testing and servicing to include replacing materials and equipment. Term of agreement shall be for 1 year with option for one-year renewal.
1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of water softeners and are based on the specific system indicated. Refer to Division 01 Section “Product Requirements.”

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

D. ASME Compliance for Steel Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01, and bear the appropriate code symbol.

E. ASME Compliance for FRP Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, where indicated.

F. NSF Standard: Provide water softeners constructed in accordance with NSF No. 44 "Standard for Cation Exchange Water Softeners."

G. Mineral Standard: Provide mineral (resin) products acceptable under state and local public health control regulations.

1.5 COORDINATION

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water softener that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

   a. Structural failures of mineral and brine tanks.
   b. Faulty operation of controls.
   c. Deterioration of metals, metal finishes, and other materials beyond normal use.
   d. Attrition loss of resin exceeding 3 percent per year.
   e. Mineral washed out of system during service run or backwashing period.
   f. Effluent turbidity greater and color darker than incoming water.
   g. Fouling of underdrain system, gravel, and resin, with turbidity or by dirt, rust, or scale from softener equipment or soft water, while operating according to manufacturer's written operating instructions.

2. Commercial Water Softener, Warranty Period: From date of Substantial Completion.

   a. Mineral Tanks: [Five] [10] <Insert number> years.
   b. Brine Tanks: [Three] [Five] <Insert number> years.
   c. Controls: [Five] [10] <Insert number> years.
   d. Underdrain Systems: [Three] [Five] <Insert number> years.
1.7 MAINTENANCE SERVICE
A. Maintenance: Submit [four] <Insert number> copies of manufacturer's "Agreement for Continued Service and Maintenance," before Substantial Completion, for Owner's acceptance. Offer terms and conditions for furnishing chemicals and providing continued testing and servicing to include replacing materials and equipment. Include one-year term of agreement with option for one-year renewal.

1.8 EXTRA MATERIALS
A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Salt for Brine Tanks: Furnish same form as and at least [four] <Insert number> times original load, but not less than 1000 lb (453.6 kg). Deliver on pallets according to the following:
      a. Food-Grade Pellet Salt: In 40- or 50-lb (18.1- or 22.7-kg) packages.
   2. Store salt on raised concrete pad where indicated on drawings. Do not store in contact with concrete floor. Concrete pad to have a rubber matt fit to size of pad on top.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Basis of Design: Per the manufacturer listed.
B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.
C. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 COMMERCIAL WATER SOFTENERS
A. Description: Factory-assembled, pressure-type water softener.
B. Single or multiple tanks as indicated, to provide total capacity of system.
   1. Manufacturers:
      a. CSI Water Treatment Systems; a division of Chandler Systems, Inc.
      b. Culligan International Company.
      c. Hellenbrand
      d. Diamond Water Conditioning.
      e. Evoqua
      f. Marlo, Inc.
   2. Comply with NSF 61, "Drinking Water System Components--Health Effects."
   3. Configuration: Multiple unit with two mineral tanks and one brine tank, factory mounted on skids.
C. Fiberglass Tanks: Fiberglass, ASME labeled for 100 psig, and hydrostatically tested at 150 psig.
   1. Tank Liner: Polyethylene, ABS, or other material suitable for potable water.
      a. Construction: Fabricated and stamped to comply with ASME Boiler and Pressure Vessel Code: Section X, "Fiber-Reinforced Plastic Pressure Vessels."
      b. Pressure Rating: 100 psig minimum.
      c. Wetted Components: Suitable for water temperatures from 40 to at least 150 deg F.
      d. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
      e. Support Legs or Skirt: Constructed of structural steel, welded to tank before testing and labeling.
      f. Upper Distribution System: Single, point type, fabricated from Schedule 40 galvanized-steel pipe and fittings.
      g. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from Schedule 40, polyvinyl chloride (PVC) pipe and fittings with individual, fine-slotted, non-clogging plastic strainers; arranged for even flow distribution through resin bed.
      h. Liner: PE, ABS, or other material suitable for potable water.
      a. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
      b. Construction: Fabricated and stamped to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels."
      c. Pressure Rating: 150 psig minimum.
      d. Wetted Components: Suitable for water temperatures from [40 to at least 100 deg F] [40 to at least 120 deg F] [40 to at least 150 deg F] <Insert temperature>.
      e. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
      f. Handholes: 4 inches round or 4 by 6 inches elliptical, in top head and lower sidewall of tanks 30 inches and smaller in diameter.
      g. Manhole: 11 by 15 inches in top head of tanks larger than 30 inches in diameter.
      h. Support Legs or Skirt: Constructed of structural steel, welded to tank [before testing and labeling].
      i. Finish: Hot-dip galvanized on exterior and interior of tank after fabrication unless tank is stainless steel.
      j. Finish: Exterior of tank spray painted with rust-resistant prime coat, 2- to 3-mil dry film thickness. Interior sandblasted and lined with epoxy-polyamide coating, 8- to 10-mil dry film thickness.
      k. Upper Distribution System: Single, point type, fabricated from galvanized-steel pipe and fittings.
      l. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, non-clogging PE strainers; arranged for even flow distribution through resin bed.
      m. Liner: PE, ABS, or other material suitable for potable water.
   4. Controls: Automatic; factory mounted on unit and factory wired.
      a. Adjustable duration of various regeneration steps.
b. Push-button start and complete manual operation.

c. Electric time clock and switch for automatic operation, except for manual return to service.

d. Sequence of Operation: Program multiport pilot-control valve to automatically pressure-actuate main operating valve through steps of regeneration.

e. Pointer on pilot-control valve shall indicate cycle of operation.

f. Means of manual operation of pilot-control valve if power fails.

5. Controls: Fully automatic; factory mounted on unit and factory wired.

a. Adjustable duration of various regeneration steps.

b. Push-button start and complete manual operation.

c. Electric time clock and switch for fully automatic operation, adjustable to initiate regeneration at any hour of day and any day of week or at fixed intervals.

d. Sequence of Operation: Program multiport pilot-control valve to automatically pressure-actuate main operating valve through steps of regeneration and return to service.

e. Pointer on pilot-control valve shall indicate cycle of operation.

f. Means of manual operation of pilot-control valve if power fails.

g. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:

1) Slow opening and closing, non-slam operation.
2) Diaphragm guiding on full perimeter from fully open to fully closed.
3) Isolated dissimilar metals within valve.
4) Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
5) Valve for single mineral-tank unit with internal automatic bypass of raw water during regeneration.
6) Sampling cocks for soft water.
7) Special tools are not required for service.

h. Flow Control: Automatic, to control backwash and flush rates over wide variations in operating pressures, and that does not require field adjustments.

1) Meter Control: Equip each mineral tank with signal-register-head water meter that will produce electrical signal indicating need for regeneration on reaching hand-set total in gallons. Design so signal will continue until reset.

2) Demand-Initiated Control: Equip single mineral-tank units with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in gallons. Design so head automatically resets to preset total in gallons for next service run.

3) Demand-Initiated Control: Equip each mineral tank of twin mineral-tank units with automatic-reset-head water meters that electrically activate cycle controllers to initiate regeneration at preset total in gallons. Design so heads automatically reset to preset total in gallons for next service run. Include electrical lockout to prevent simultaneous regeneration of both tanks.

4) Demand-Initiated Control: Equip each mineral tank of twin mineral-tank units with automatic-reset-head water meter in common outlet header that electrically activates cycle controller to automatically regenerate one mineral tank at preset total in gallons and divert flow to other tank. Set to repeat with other tank. Include electrical lockout to prevent simultaneous regeneration of both tanks.
5) Demand-Initiated Control: Equip each mineral tank of multiple mineral-tank units with automatic-reset-head water meters that electrically activate cycle controllers to automatically regenerate at preset total in gallons. Design so heads automatically reset to preset total in gallons for next service run. Include electrical lockouts to prevent simultaneous regeneration of more than one tank.

6) Demand-Initiated Control: Equip each mineral tank of multiple mineral-tank units with automatic-reset-head water meter in common outlet header that electrically activates cycle controller to automatically regenerate one mineral tank at preset total in gallons and divert flow to other tanks. Set to repeat with other tanks. Include electrical lockouts to prevent simultaneous regeneration of more than one tank.

6. Brine Tank: Combination measuring and wet-salt storing system.
   a. Tank and Cover Material: Fiberglass, 3/16 inch thick; or molded PE, 3/8 inch thick.
   b. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
   c. Size: Large enough for at least four regenerations at full salting.

7. Factory-Installed Accessories:
   a. Piping, valves, tubing, and drains.
   b. Sampling cocks and hard water inlet and soft water outlet for each tank.
   c. Main-operating-valve position indicators.
   d. Water meters.
   e. Pressure gauges for hard water inlet and soft water outlet for each tank.

D. Capacity and Characteristics:

1. Service: [Cold] [Hot] water.

2. Water Analysis:
   a. Hardness: <Insert grains/gal. or ppm.>
   d. Concentration: <Insert pH.>
   e. Inlet Water Pressure: <Insert psig.>
   f. Water Temperature: <Insert deg F.>

3. Continuous Service Flow Rate: <Insert number> gpm at 15-psig pressure drop.

4. Peak Service Flow Rate: <Insert number> gpm at 25-psig pressure drop.

5. Water Meter Size: <Insert NPS.>

6. Manifold Pipe Size: <Insert NPS.>

7. Backwash to Drain Pipe Size: <Insert.>

8. Water Consumption: <Insert gal./day.>

9. Water Demand: <Insert hours/day.>

10. Number of Mineral Tanks: [One] [Two] [Three] <Insert number>.


13. Electrical Characteristics:
   a. Volts: <Insert value.>
   b. Phases: <Insert value.>
   c. Hertz: <Insert value.>
   d. Full-Load Amperes: <Insert value.>
2.3 CHEMICALS

A. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock.
   1. Exchange Capacity: 30,000 grains/cu. ft of calcium carbonate of resin when regenerated with 15 lb of salt.

B. Salt for Brine Tanks: High-purity pellet sodium chloride, free of dirt and foreign material. Rock and granulated forms are not acceptable.
   1. Form: Processed, food-grade salt pellets

2.4 WATER TESTING SETS

A. Description: Manufacturer's standard water-hardness testing apparatus and chemicals with testing procedure instructions. Include metal container suitable for wall mounting.

2.5 SOURCE QUALITY CONTROL

A. Hydrostatically test mineral tanks before shipment to minimum of one and one-half times pressure rating.

B. Prepare test reports.

2.6 Building Automation System.

A. General Alarm Signal.

B. Low brine level Signal.

PART 3 - EXECUTION

3.1 CONCRETE BASES

A. Install concrete bases of dimensions indicated for commercial water softeners. Refer to Division 22 Section "Basic Division 22 Requirements."
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevation required for proper attachment to supported equipment.

B. Cast-in-place concrete materials and placement requirements are specified in Division 03.
3.2 WATER SOFTENER INSTALLATION

A. Install commercial water softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.

B. Install brine lines and fittings furnished by equipment manufacturer but not specified to be factory installed.

C. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

D. Install water testing sets mounted on wall, unless otherwise indicated, and near water softeners.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Make piping connections between water-softener-unit headers and dissimilar-metal water piping with dielectric fittings. Dielectric fittings are specified in Division 22 Section "Common Work Results for Plumbing."

D. Install shutoff valves on raw-water inlet and soft-water outlet piping of each mineral tank, and on inlet and outlet headers.
   1. Metal general-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
   2. Plastic valves are specified in Division 22 Section "Domestic Water Piping."
   3. Exception: Water softeners with factory-installed shutoff valves at locations indicated.

E. Install pressure gages on raw-water inlet and soft-water outlet piping of each mineral tank. Pressure gages are specified in Division 22 Section "Meters and Gages for Plumbing Piping."
   1. Exception: Water softeners with factory-installed pressure gages at locations indicated.
   2. Exception: Household water softeners.
   3. Exception: Water softeners in hot-water service.

F. Install valved bypass water piping around water softeners.
   1. Metal general-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
   2. Plastic valves are specified in Division 22 Section "Domestic Water Piping."
   3. Water piping is specified in Division 22 Section "Domestic Water Piping."
   4. Exception: Household water softeners.
   5. Exception: Water softeners in hot-water service.

G. Install drains as indirect wastes to spill into open drains or over floor drains.

H. Ground equipment according to Division 26 Section "Grounding and Bonding."

I. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

J. Connect water piping to units with shutoff valves and unions and provide full-size valved bypass around unit.
K. Install brine lines and fittings furnished by manufacturer but not specified to be factory mounted.

3.4 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
   3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning water softeners that do not pass tests and inspections and retest as specified above.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer’s written instructions.

B. Add water to brine tanks and fill with salt.
   1. Household Water Softeners: Processed [food-grade salt pellets] [plain salt pellets] [crystallized solar salt] <Insert salt form>.
   2. Commercial Water Softeners: [Plain salt pellets] [Crystallized solar salt] [Plain, brine block salt] [Food-grade salt pellets] <Insert salt form>.

C. Sample water softener effluent after startup and at three consecutive seven-day intervals (total of four samples), and prepare certified test reports for required water performance characteristics. Comply with the following:
   2. ASTM D 1067, "Test Methods for Acidity or Alkalinity of Water."
   4. ASTM D 1126, "Test Method for Hardness in Water."
   5. ASTM D 1129, "Terminology Relating to Water."
   7. ASTM D 1888, "Test Methods for Particulate and Dissolved Matter in Water."

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water softeners. Refer to Division 01 "Demonstration and Training" Section.

3.7 COMMISSIONING

A. Perform the following before start-up final checks:
   1. Water piping systems tests completed.
   2. Load Softener Tank: Install gravel to cover lower distribution system, add water; smooth gravel surface and add softening mineral.
3. Load Brine Tank: Add water and fill tank with salt.
4. Check for piping connections leaks.
5. Test operation of safety controls and devices.
6. Test all alarm signals to work properly.

B. Perform the following start-up procedures:
   1. Energize circuits.
   2. Adjust operating controls.

END OF SECTION 223100
SECTION 223400 - DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following fuel-fired water heaters:
1. Instantaneous, tankless, gas water heaters.
2. Commercial, high-efficiency, gas water heaters.
3. Electric water heaters.
5. Compression tanks.

1.2 DEFINITIONS
A. LP Gas: Liquefied-petroleum fuel gas.

1.3 SUBMITTALS
A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
B. Shop Drawings: Diagram power, signal, and control wiring.
C. Product Certificates: For each type of commercial and instantaneous water heater, signed by product manufacturer.
D. Manufacturer Seismic Qualification Certification: Submit certification that commercial water heaters, accessories, and components will withstand seismic forces defined in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
      b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
E. Source quality-control test reports.
F. Field quality-control test reports.
G. Operation and Maintenance Data: For water heaters to include in emergency, operation, and maintenance manuals.
H. Warranty: Special warranty specified in this Section.
1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of water heaters through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of water heaters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASME Compliance:
   1. Where ASME-code construction is indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.
   2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.

E. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

F. UL Standards: Provide water heaters complying with the following:
   1. UL 732, "Oil Fired Water Heaters."

G. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Water heaters shall be listed by a NRTL. The term "NRTL" shall be defined in OSHA Regulation 1910.7.

H. AGA Standards: Provide water heaters that bear the label of the American Gas Association.


J. Design Concept: The drawings indicated types and capacities of water heaters and are based on specific descriptions and manufacturers indicated. Water heaters having equal performance characteristics by other manufacturers may be considered provided that deviations in capacities, dimensions, operation, or other characteristics are minor and do not change the design concept or intended performance as judged by the Architect. Burden of proof for equality of water heaters is on the proposer.

1.5 COORDINATION

A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired water heaters that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures including storage tank and supports.
      b. Faulty operation of controls.
      c. Deterioration of metals, metal finishes, and other materials beyond normal use.
2. Warranty Period(s): From date of Substantial Completion:
   a. Instantaneous, Gas Water Heaters:
      1) Heat Exchanger: Five years.
      2) Controls and Other Components: Three years.
   b. Commercial, Gas Water Heaters:
      1) Storage Tank: Five years.
      2) Controls and Other Components: Five years.
   c. Compression Tanks: One year(s).

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Basis of Design: Per the manufacturer listed on the schedule on the drawings.
   B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.
   C. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
      1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 INSTANTANEOUS, GAS WATER HEATERS
   A. Description: Comply with ANSI Z21.10.3/CSA 4.3, except storage is not required.
      1. Manufacturers:
         a. Navien.
         b. NORITZ America Corporation.
         c. Rinnai.
         d. Takagi Industrial Co. USA, Inc.
         e. Intellihot
      2. Construction: Copper piping or tubing complying with NSF 61 barrier materials for potable water, without storage capacity.
         b. Pressure Rating: 150 psig (1035 kPa).
         c. Heat Exchanger: Copper tubing.
         d. Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2.
         f. Automatic Ignition: Manufacturer's proprietary system for automatic, gas ignition.
         g. Temperature Control: Adjustable thermostat.
         h. Jacket: Metal with enameled finish or plastic.

2.3 INSTANTANEOUS, STEAM WATER HEATERS
   A. Description: Comply with ANSI Z21.10.3/CSA 4.3, except storage is not required.
      1. Manufacturers:
2. Construction: Copper or copper alloy with NSF 61 barrier materials for potable water, without storage capacity.
   c. Heat Exchanger: Copper tubing.
   d. Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2.
   e. Temperature Control: Integral electronic steam control.
   f. Jacket: Metal with enameled finish or plastic.

2.4 COMMERCIAL, GAS WATER HEATERS


1. Manufacturers:
   a. AERCO International.
   b. Lochinvar Corporation.
   c. PVI Industries.
   d. Patterson-Kelley.
   f. Smith, A. O. Water Products Company.
   g. State.
   h. HTP.
   i. Bock.

2. Description: Manufacturer's proprietary design to provide at least 95 percent combustion efficiency at optimum operating conditions. Following features and attributes may be modified or omitted if water heater otherwise complies with requirements for performance.

   a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
      1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
      2) NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
   b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   c. Lining: [Cement] [Glass] [Nickel plate] [Phenolic coating] [Sheet copper] complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.

4. Factory-Installed, Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.
   b. Dip Tube: Provide unless cold-water inlet is near bottom of tank.
2. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
3. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
5. Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

5. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for high-efficiency water heaters and for [natural-gas] [LP-gas] fuel.
7. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.

2.5 OIL-FIRED WATER HEATERS
A. Commercial, Oil-Fired Water Heaters

   a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
      1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
      2) NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
   b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   c. Lining: Cement, Stainless steel or Sheet copper complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.

2. Factory-Installed, Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.
   b. Dip Tube: Provide unless cold-water inlet is near bottom of tank.
   c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
   d. Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2.
   e. Jacket: Steel with enameled finish, over factory installed insulation in compliance with ASHRAE/IESNA 90.1 or ASHRAE 90.2.
   f. Temperature Control: Adjustable thermostat.
   g. Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
2.6 INSTANTANEOUS ELECTRIC WATER HEATERS
A. Flow-Control, Instantaneous Electric Water Heaters: Comply with UL 499 for tankless electric (water heater) heating appliance.
   1. Manufacturers:
      a. Chronomite Laboratories, Inc.
      b. Controlled Energy Corporation.
      c. Eemax, Inc.
      d. Hot Aqua, Inc.
      e. Hubbell
   2. Construction: Copper piping or tubing complying with NSF 61 barrier materials for potable water, without storage capacity.
      d. Safety Control: High-temperature-limit cutoff device or system.
      e. Jacket: Aluminum or steel with enameled finish over factory installed insulation. complying with ASHRAE/IESNA 90.1 or ASHRAE 90.2.

2.7 PLATE HEAT EXCHANGERS
A. Brazed-Plate Heat Exchangers:
B. Manufacturers:
   1. Alfa Laval, Inc.
   2. Bell & Gossett; ITT Industries.
   3. Doucette Industries, Inc.
   4. Polaris Plate Heat Exchangers.
   5. Triangle Tube/Phase III.
C. Description: Assembly of heat-exchanger plates, permanently brazed together, for using [heating hot water] [steam] to heat domestic water.
   2. Plate Construction: Vented, double wall.
   3. Plate Material: ASTM A 666, Type 316 stainless steel.
D. Condensate Outlet Pipe Size: provide steam trap and condensate to support unit and match piping size.
   1. Domestic Water Inlet and Outlet Pipe Size: Refer to drawings and details.
E. Manufacturers:
   1. Alfa Laval, Inc.
   2. APV Systems.
   3. Armstrong Pumps, Inc.
   4. Bell & Gossett; ITT Industries.
   5. FES Systems Inc.
9. Tranter PHE, Inc.
10. Triangle Tube/Phase III.

F. Description: Assembly of nonfixed-position, heat-exchanger plates, with frame, for using [heating hot water] [steam] to heat domestic water.
   2. Frame:

G. Carrying and Guide Bars: [Carbon steel] [Stainless steel] <Insert other>.
   1. Fixed, Frame Plate; Pressure Plate; Support Column; and Nuts and Bolts: Carbon steel.

H. Channel Plates:
   I. Type: Vented, double wall.
      1. Material: ASTM A 666, Type [304] [304 or 316] [316] stainless steel.
      2. Gasket Material: Butyl or acrylonitrile-butadiene rubber, suitable for potable water.

J. Connections: Stainless steel suitable for potable water. Refer to the drawings and details.
   1. NPS 2 (DN 50) and Smaller: Threaded.
   2. NPS 2-1/2 (DN 65) and Larger: Flanged.

K. Protective Shroud: Steel, covering channel plates.

L. Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire heat exchanger except connections.

2.8 COMPRESSION TANKS

A. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.

B. Manufacturers:
   1. AMTROL Inc.
   2. Armstrong Pumps, Inc.
   3. Flexcon Industries.
   4. Honeywell Sparco
   5. Taco, Inc.
   6. Wessels Co.

C. Construction:
   1. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
      a. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.

2.9 WATER HEATER ACCESSORIES


DOMESTIC WATER HEATERS
B. Gas Pressure Regulators: ANSI Z21.18, appliance type. Include pressure rating, capacity, and pressure differential required between gas supply and water heater.

C. Gas Automatic Valves: ANSI Z21.21, appliance, electrically operated, on-off automatic valve.

D. Combination Temperature and Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select each relief valve with sensing element that extends into storage tank.

   1. Pressure Relief Valves: Include pressure setting less than working-pressure rating of water heater.

   1. Indicate on Drawings where each type of water heater support, in four paragraphs below, is required. Delete support types not required. Water heaters can also be installed at or above ceilings on suspended platforms or brackets.

G. Water Heater Stand and Drain Pan Units: High-density-polyethylene-plastic, 18-inch- (457-mm-) high, enclosed-base stand complying with IAPMO PS 103 and IAS No. 2. Include integral or separate drain pan with raised edge and NPS 1 (DN 25) drain outlet with ASME B1.20.1 pipe thread.

H. Water Heater Stands: Water heater manufacturer's factory-fabricated steel stand for floor mounting and capable of supporting water heater and water. Provide dimension that will support bottom of water heater a minimum of 18 inches (457 mm) above the floor.

I. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.

J. Drain Pans: Corrosion-resistant metal with raised edge. Provide dimensions not less than base of water heater and include drain outlet not less than NPS 3/4 (DN 20).

K. Piping Manifold Kits: Water heater manufacturer's factory-fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that is capable of isolating each water heater and of providing balanced flow through each water heater.

L. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.


2.10 SOURCE QUALITY CONTROL
A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial water heater storage tanks before shipment to minimum of one and one-half times pressure rating.

C. Prepare test reports.

2.11 Building Automation System
A. List of Signals
   1. Trouble
PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

A. Install commercial water heaters on concrete bases.
   1. Concrete base construction requirements are specified in Division 22 Section "Basic Division 22 Requirements."

B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer’s recommended clearances. Arrange units so controls and devices needing service are accessible.

C. Install gas water heaters according to NFPA 54.

D. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.

E. Install gas pressure regulators on gas supplies to gas water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.

F. Install automatic gas valves on gas supplies to gas water heaters, if required for operation of safety control.

G. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

H. Install [combination temperature and] pressure relief valves in water piping for water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

I. Install water heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 Section "Domestic Water Piping Specialties" for hose-end drain valves.

J. Install thermometer on outlet piping of water heaters. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

K. Install pressure gage(s) on [inlet and] outlet piping of commercial, fuel-fired water heater piping. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.

L. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve and thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves and to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

M. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.
N. Fill water heaters with water.
O. Charge compression tanks with air.

3.2 CONNECTIONS
A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.
C. Ground equipment according to Division 26 Section "Grounding and Bonding."
D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL
A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.
B. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   4. Test all alarm signals for proper execution.
C. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

3.4 DEMONSTRATION
A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instantaneous and commercial water heaters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 223400
SECTION 224000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following plumbing fixtures and related components:

1. Water Closets.
2. Urinals.
3. Lavatories.
4. Sinks.
5. Service Sinks.
7. Clinical Service Sink.
8. Mop Basin.
10. Dialysis Box.
13. Hose Bibbs.
14. Wall Hydrant.
15. Roof Hydrant.
16. Wall Outlet Boxes.

B. Related Sections include the following:

1. Division 10 Section "Toilet, Bath, and Laundry Accessories."
2. Division 22 Section "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.

1.2 DEFINITIONS


B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, showerheads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

F. FRP: Fiberglass-reinforced plastic.

G. PMMA: Polymethyl methacrylate (acrylic) plastic.

H. PVC: Polyvinyl chloride plastic.

1.3 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

D. Warranty: Special warranty specified in this Section.

E. Sustainability/Sustainable Submittal:
   1. Product Data for Prerequisite and Credit WE 1 and 3: Documentation indicating flow and water consumption requirements.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
   1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


E. NSF Standard: Comply with NSF 61, "Drinking Water System Components – Health Effects," for fixture materials that will be in contact with potable water.

F. WaterSense: All low-flow fixtures to bear WaterSense label for Sustainability/Sustainable projects.

G. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

H. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
   3. Vitreous-China Fixtures: ASME A112.19.2M.

I. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
   1. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
3. Hose-Connection Vacuum Breakers: ASSE 1011.

J. Comply with the following applicable standards and other requirements specified for shower faucets:

1. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
2. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.

K. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

2. Brass and Copper Supplies: ASME A112.18.1.

L. The installation of the plumbing fixtures shall include all required components, fittings and assembly to provide proper operating systems in compliance with all authorities having jurisdiction.

M. Comply with the following applicable standards and other requirements specified for miscellaneous components:

2. Floor Drains: ASME A112.6.3.
5. Off-Floor Fixture Supports: ASME A112.6.1M.
1.5 WARRANTY

A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components of whirlpools that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures of unit shell.
   b. Faulty operation of controls, blowers, pumps, heaters, and timers.

1.6 EXTRA MATERIALS

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: Per the manufacturer listed.

B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

1. PVC drain traps are acceptable in lieu of polished chrome provided trap is enclosed in trap wrap or concealed in casework.

2.2 FIXTURES


1. Fixture:
   a. Manufacturer: Kohler.
      1) Alternates (new construction only):
         a) American Standard.
         b) Zurn.
   b. Model: Highcliff Ultra K-96057-0.

2. Flush Valve:
   a. Manufacturer: Sloan.
   b. Model: 111 ESS-1.6-DFB-TMO.
      1) Sensor activated with manual override, 120 V transformer direct wire.
      2) Diaphragm with dual filtered fixed bypass.

3. Seat:
   a. Manufacturer: Bemis.
   b. Model: 2155SSCT.
      1) Open front, with self-sustaining check hinges, no cover.

B. WC-2 – Water Closet: Floor mounted, rear outlet, vitreous china elongated bowl with dual level flush valve. (Patient rooms and Staff Toilet rooms where structural components won’t allow for floor outlet).

1. Fixture:
a. Manufacturer: Kohler.
   1) Alternates (new construction only):
      a) American Standard.
      b) Zurn.

b. Model: Anglesey K-4352. If for patient room add L to model number for bedpan lugs, see WC-5 for flush valve and seat models.

2. Flush Valve:
   a. Manufacturer: Sloan.
   b. Model: WES 111-DFB.
      1) Dual flush with green handle, 1.1 GPF for liquid lift up, 1.6 GPF for solid push down.
      2) Diaphragm with dual filtered fixed bypass.

3. Seat:
   a. Manufacturer: Bemis.
   b. Model: 2155SSCT.
      1) Open front, with self-sustaining check hinges, no cover.

C. WC-3 – Water Closet: Floor mounted, floor outlet, vitreous china elongated bowl with direct wire electronic flush valve. (Staff Toilet Rooms).

1. Fixture:
   a. Manufacturer: Kohler.
      1) Alternates (new construction only):
         a) American Standard.
         b) Zurn.

b. Model: Highcliff Ultra K-96057-0.

2. Flush Valve:
   a. Manufacturer: Sloan.
   b. Model: WES 111-DFB.
      1) Dual flush with green handle, 1.1 GPF for liquid lift up, 1.6 GPF for solid push down.
      2) Diaphragm with dual filtered fixed bypass.

3. Seat:
   a. Manufacturer: Bemis.
   b. Model: 2155SSCT.
      1) Open front, with self-sustaining check hinges, no cover.

D. WC-4 – Water Closet: Floor mounted, floor outlet, vitreous china elongated bowl with direct wire electronic flush valve with wider toilet seat. (Bariatric Toilet Rooms).

1. Fixture:
      1) Alternates (new construction only):
a) Kohler.
   b) Zurn.

b. Model: Madera 3641001.020.

2. Flush Valve:
   a. Manufacturer: Sloan.
   b. Model: WES 111-DFB.
      1) Dual flush with green handle, 1.1 GPF for liquid lift up, 1.6 GPF for solid push down.
      2) Diaphragm with dual filtered fixed bypass.

3. Seat:
   a. Manufacturer: Big John.
   b. Model: 4W.
      1) Open front elongated, with self-sustaining check hinges, no cover.

E. WC-5 Water Closet: Floor mounted, floor outlet, vitreous china elongated bowl with flush valve and bedpan washer. Bowl is molded to have bedpan lugs for bedpan and fit a "Collection Hat". (Patient Rooms).

1. Fixture:
   a. Manufacturer: Kohler or American Standard.
   b. Model: Kohler Highcliff Ultra K-96057-L-0.

2. Flush Valve:
   a. Manufacturer: Sloan.
   b. Model: BPW 1150-DFB.
      1) Chrome plated 26-1/2" tall Low consumption 1.6 GPF flushometer with Grab Bar offset.
      2) Diaphragm with dual filtered fixed bypass.

3. Seat:
   a. Manufacturer: Bemis.
   b. Model: 2155SSCT.
      1) Open front, with self-sustaining check hinges, no cover.

F. U-1 – Urinal: Wall mounted washout with concealed trap exposed 3/4" top spud with electronic flush valve. (Patient and Staff Toilet Rooms).

1. Basin:
   a. Manufacturer: Toto.
      1) Alternates (new construction only):
         a) American Standard.
         b) Zurn.
   b. Model: UT104E.
      1) Rim Elevation 24" AFF.
2. **Flush Valve:**
   a. Manufacturer: Sloan.
   b. Model: 186 ESS-0.5-DFB-TMO.
      1) Sensor activated with manual override, 120 V transformer direct wire.
      2) Diaphragm with dual filtered fixed bypass.

G. **U-2 – Urinal:** Wall mounted washout with concealed trap exposed ¾" top spud with electronic flush valve.
   1. **Basin:**
      a. Manufacturer: Toto.
         1) Alternates (new construction only):
            a) American Standard.
            b) Zurn.
      b. Model: UT104E.
         1) Rim Elevation 17" AFF.

2. **Flush Valve:**
   a. Manufacturer: Sloan.
   b. Model: 186 ESS-0.5-DFB-TMO.
      1) Sensor activated with manual override, 120 V transformer direct wire.
      2) Diaphragm with dual filtered fixed bypass.

H. **L-1 – Lavatory:** Wall hung vitreous china, hand wash lavatory with chrome plated gooseneck faucet with wrist blade handles. (Staff Areas).
   1. **Fixture:**
      a. Manufacturer: Kohler.
         1) Alternates (new construction only):
            a) American Standard.
            b) Zurn.

2. **Faucet:**
   a. Manufacturer: Chicago Faucets.
   b. Model: 786-E35ABCP.
      1) Ceramic Cartridge.

3. **Trap:**
   a. 1-1/4" x 1-1/2" PVC p-trap.

4. **Drain:**
   b. Model: 155WC. Offset drain.

5. **Stops:**
1. Fixture:

2. Faucet:
   a. Manufacturer: Chicago Faucets.
   b. Model: 786-E35ABCP.
      1) Ceramic Cartridge.

3. Trap:
   a. 1-1/4" x 1-1/2" PVC p-trap.

4. Drain:
   b. Model: 155WC. Offset drain.

5. Stops:
   b. Model: LFST09.
      1) 1/2" compression to 3/8" compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
1) Lead-free, stainless-steel braid, 3/8" compression to 1/2" FIP, 12" length.

7. Accessories:
   a. Trap Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.
   b. Individual-Fixture, Water Tempering Valve:
      1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

J. L-3 – Lavatory: Wall mounted vitreous china with chrome plated combination gooseneck faucet and integrated emergency eyewash with wrist blade handles. (Staff Areas).

1. Fixture:
   a. Manufacturer: Kohler.
      1) Alternates (new construction only):
         a) American Standard.
         b) Zurn.

2. Faucet:
   a. Manufacturer: Speakman.
   b. Model: SEF-1801.
      1) With ASSE 1071 compliant thermostatic mixing valve installed below counter top.
      2) Output temperature set to 90°F.
      3) Lift top eyewash activation.
      4) Check stops between mixing valve and angle stops and faucet.

3. Trap:
   a. 1-1/4" x 1-1/2" PVC p-trap.

4. Drain:
   b. Model: 155WC. Offset drain.

5. Stops:
   b. Model: LFST09.
      1) 1/2" compression to 3/8" compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8" compression to 1/2" FIP, 12" length.

7. Accessories:
a. Trap Wrap:
   1) Manufacturer: Proflow.
   2) Model: PF202WH.

b. Individual-Fixture, Water Tempering Valve:
   1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

K. L-4 – Lavatory: Integral bowl by others with chrome plated gooseneck faucet with wrist blade handles. (Staff Areas).
   1. Fixture:
      a. Manufacturer: Integral, see Architecture drawings.
   2. Faucet:
      a. Manufacturer: Chicago Faucets.
      b. Model: 786-E35ABCP.
         1) Ceramic Cartridge.
   3. Trap:
      a. 1-1/4" x 1-1/2" PVC p-trap.
   4. Drain:
      b. Model: 155WC. Offset drain.
   5. Stops:
      b. Model: LFST09.
         1) 1/2" compression to 3/8" compression with wheel handle.
   6. Supplies:
      a. Manufacturer: Mainline.
      b. Model: MLB112AF.
         1) Lead-free, stainless-steel braid, 3/8" compression to 1/2" FIP, 12" length.
   7. Accessories:
      a. Trap Wrap:
         1) Manufacturer: Proflow.
         2) Model: PF202WH.
      b. Individual-Fixture, Water Tempering Valve:
         1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

L. L-5 – Lavatory: Wall mounted vitreous china with chrome plated gooseneck faucet with wrist blade handles and wall mounted swing down emergency eyewash. (Staff Areas).
   1. Fixture:
      a. Manufacturer: Kohler.
1) Alternates (new construction only):
   a) American Standard.
   b) Zurn.


2. Faucet:
   a. Manufacturer: Chicago Faucets.
   b. Model: 786-E35ABCP.

1) Ceramic Cartridge.

3. Trap:
   a. 1-1/4" x 1-1/2" PVC p-trap.

4. Drain:
   b. Model: 155WC. Offset drain.

5. Stops:
   b. Model: LFST09.

   1) 1/2" compression to 3/8" compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.

   1) Lead-free, stainless-steel braid, 3/8" compression to 1/2" FIP, 12" length.

7. Accessories:
   a. Trap Warp:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.
   b. Individual-Fixture, Water Tempering Valve:
      1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.
   c. Swing Down Emergency Eyewash:
      1) Manufacturer: Guardian.
      2) Model: G1898.

      a) Shaft is to be field measured and factory bend.
      3) Miscellaneous: With ASSE 1071 compliant, Bradley S19-2000 EFX8 thermostatic mixing valve, installed below counter top or fixture, and output set to 90°F.
      4) Provide swing check valves upstream of mixing valve.
M. L-6 – Lavatory: Wall mounted vitreous china with chrome plated gooseneck faucet with wrist blade handles, wall mounted swing down emergency eyewash, and solids interceptor trap. (Staff Areas).

1. Fixture:
   a. Manufacturer: Kohler.
      1) Alternates (new construction only):
         a) American Standard.
         b) Zurn.

2. Faucet:
   a. Manufacturer: Chicago Faucets.
   b. Model: 786-E35ABCP.
      1) Ceramic Cartridge.

3. Trap:
   a. Manufacturer: Zurn.
   b. Model: Z1180.
      1) Acid resistant solids interceptor for on floor mounting with removable sediment bucket.

4. Drain:
   b. Model: 155AECO.
      1) Heavy Cast brass chrome plated open grid with 17 GA 6” tailpiece.

5. Stops:
   b. Model: LFST09.
      1) 1/2” compression to 3/8” compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8” compression to 1/2” FIP, 12” length.

7. Accessories:
   a. Trap Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.
   b. Individual-Fixture, Water Tempering Valve:
      1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.
c. Swing Down Emergency Eyewash:
   1) Manufacturer: Guardian.
   2) Model: G1898.
      a) Shaft is to be field measured and factory bend.
   3) Miscellaneous: With ASSE 1071 compliant, Bradley S19-2000 EFX8 thermostatic mixing valve, installed below counter top or fixture, and output set to 90°F.

N. L-7 – Lavatory: Wall hung vitreous china, hand wash lavatory with sensor activated chrome plated gooseneck faucet. (<Nursing Department Isolation Patient Toilet Room, Nursery Infant Intensive Care Unit, Surgical Recovery Room, Clinical or Outpatient Department Dental Operating Room, Clinical or Outpatient Department Eye Exam Room, Clinical or Outpatient Department Ear, Nose, and Throat Exam Room>).
   1. Fixture:
      a. Manufacturer: Kohler.
         1) Alternates (new construction only):
            a) American Standard.
            b) Zurn.
   2. Faucet:
      a. Manufacturer: Chicago Faucets.
         1) Ceramic Cartridge.
   3. Trap:
      a. 1-1/4" x 1-1/2" PVC p-trap.
   4. Drain:
      b. Model: 155WC. Offset drain.
   5. Stops:
      b. Model: LFST09.
         1) 1/2" compression to 3/8" compression with wheel handle.
   6. Supplies:
      a. Manufacturer: Mainline.
      b. Model: MLB112AF.
         1) Lead-free, stainless-steel braid, 3/8" compression to 1/2" FIP, 12" length.
   7. Carrier: Floor mounted with arms.
      a. Manufacturer: Zurn.
      b. Model: Z1231.
8. Accessories:
   a. Supplies Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF299WH two required.
   b. Individual-Fixture, Water Tempering Valve:
      1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

O. S-1 – Single Compartment Sink: Stainless steel sink drop-in with chrome plated gooseneck faucet with wrist blade handles. (Staff Areas).
   1. Fixture:
      a. Manufacturer: Elkay.
         1) Alternates:
            a) Just.
         1) 6-1/2” deep bowl.
   2. Faucet:
      a. Manufacturer: Chicago Faucets.
         1) Alternates:
            a) T&S Brass.
      b. Model: 786-E35ABCP.
         1) Ceramic Cartridge.
   3. Trap:
      a. 1-1/2” x 1-1/2” PVC p-trap.
   4. Drain:
      a. Manufacturer: Elkay.
         1) Nickel plated brass body with grid strainer, fits 3-1/2” opening, nickel plated brass 1-1/2” x 4” tailpiece.
   5. Stops:
      b. Model: LFST09.
         1) 1/2” compression to 3/8” compression with wheel handle.
   6. Supplies:
      a. Manufacturer: Mainline.
      b. Model: MLB112AF.
         1) Lead-free, stainless-steel braid, 3/8” compression to 1/2” FIP, 12” length.
   7. Accessories:
a. Trap Wrap:
   1) Manufacturer: Proflow.
   2) Model: PF202WH.

b. Individual-Fixture, Water Tempering Valve:
   1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

P. S-2 – Single Compartment Sink: Stainless steel sink drop-in with chrome plated gooseneck faucet with wrist blade handles. (Staff Areas).

1. Fixture:
   a. Manufacturer: Elkay.
      1) Alternates:
         a) Just.

2. Faucet:
   a. Manufacturer: Chicago Faucets.
      1) Alternates:
         a) T&S Brass.

   b. Model: LRAD2219.
      1) 6-1/2" deep bowl.

3. Trap:
   a. 1-1/2" x 1-1/2" PVC p-trap.

4. Drain:
   a. Manufacturer: Elkay.
      1) Nickel plated brass body with grid strainer, fits 3-1/2" opening, nickel plated brass 1-1/2" x 4" tailpiece.

5. Stops:
   b. Model: LFST09.
      1) 1/2" compression to 3/8" compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8" compression to 1/2" FIP, 12" length.

7. Accessories:
   a. Trap Wrap:
1) Manufacturer: Proflow.
2) Model: PF202WH.

b. Individual-Fixture, Water Tempering Valve:
   1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

Q. S-3 – Single Compartment Sink: Integral Bowl by others with chrome plated gooseneck faucet with wrist blade handles. (Staff Areas).

1. Fixture:

2. Faucet:
   a. Manufacturer: Chicago Faucets.
      1) Alternates:
         a) T&S Brass.
   b. Model: 786-E35ABCP.
      1) Ceramic Cartridge.

3. Trap:
   a. 1-1/2" x 1-1/2" PVC p-trap with clean out plug.

4. Drain:
   a. Manufacturer: Elkay.
      1) Nickel plated brass body with grid strainer, fits 3-1/2" opening, nickel plated brass 1-1/2" x 4" tailpiece.

5. Stops:
   b. Model: LFST09.
      1) 1/2" compression to 3/8" compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8" compression to 1/2" FIP, 12" length.

7. Accessories:
   a. Trap Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.
   b. Individual-Fixture, Water Tempering Valve:
      1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.
R. S-4 – Double Compartment Sink: Scullery style stainless steel sink on support legs with drain board on right side with swing chrome plated faucet. (Staff Areas).

1. Fixture:
   a. Manufacturer: Elkay.
   1) Alternates:
      a) Just.
   b. Model: SS8248R.

2. Faucet:
   a. Manufacturer: Elkay.
   1) Alternates:
      a) T&S Brass.
   b. Model: LK940AT14L2S.
      1) Ceramic Cartridge.

3. Trap:
   a. 1-1/2" x 1-1/2" PVC p-trap with clean out plug.

4. Drain:
   a. Manufacturer: Elkay.
      1) Quantity of two (2) required.
      2) Nickel plated brass body with grid strainer, fits 3-1/2" opening, nickel plated brass 1-1/2" x 4" tailpiece.

5. Stops:
   b. Model: LFST09.
      1) 1/2" compression to 3/8" compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8" compression to 1/2" FIP, 12" length.

7. Accessories:
   a. Trap Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.

S. S-5 – Single Compartment Sink: Stainless steel drop in sink with chrome plated gooseneck faucet with wrist blade handles. (Staff Areas).

1. Fixture:
   a. Manufacturer: Elkay.
1) Alternates:
   a) Just.

b. Model: LRAD1517.

2. Faucet:
   a. Manufacturer: Chicago Faucets.
      1) Alternates:
         a) T&S Brass.
      b. Model: 786-E35ABCP.
         1) Ceramic Cartridge.

3. Trap:
   a. 1-1/2" x 1-1/2" PVC p-trap with clean out plug.

4. Drain:
   a. Manufacturer: Elkay.
      1) Nickel plated brass body with grid strainer, fits 3-1/2" opening, nickel plated brass 1-1/2" x 4" tailpiece.

5. Stops:
   b. Model: LFST09.
      1) 1/2" compression to 3/8" compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8" compression to 1/2" FIP, 12" length.

7. Accessories:
   a. Trap Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.
   b. Individual-Fixture, Water Tempering Valve:
      1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

T. S-6 – Two Compartment Sink: Scullery style stainless steel sink on support legs with drain board on left side with swing chrome plated faucet. (Staff Areas).

1. Fixture:
   a. Manufacturer: Elkay.
      1) Alternates:
         a) Just.
b. Model: SS8248L.

2. Faucet:
   a. Manufacturer: Elkay.
      1) Alternates:
         a) T&S Brass.
   b. Model: LK940AT14L2S.
      1) Ceramic Cartridge.

3. Trap:
   a. 1-1/2" x 1-1/2" PVC p-trap with clean out plug.

4. Drain:
   a. Manufacturer: Elkay.
      1) Quantity of two (2) required.
      2) Nickel plated brass body with grid strainer, fits 3-1/2" opening, nickel plated brass 1-1/2" x 4" tailpiece.

5. Stops:
   b. Model: LFST09.
      1) 1/2" compression to 3/8" compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8" compression to 1/2" FIP, 12" length.

7. Accessories:
   a. Trap Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.

U. S-7 – Double Compartment Sink: Drop-in stainless steel sink with deep bowls and chrome plated swing gooseneck faucet with wrist blade handles. (Staff Areas).

1. Fixture:
   a. Manufacturer: Elkay.
      1) Alternates:
         a) Just.
   b. Model: DLR331910.

2. Faucet:
   a. Manufacturer: Chicago Faucets.
      1) Alternates:
a) T&S Brass.
   b. Model: 786-GN8AE36ABCP.
      1) Ceramic Cartridge.

3. Trap:
   a. 1-1/2” x 1-1/2” PVC p-trap with clean out plug.

4. Drain:
   a. Manufacturer: Elkay.
      1) Quantity of two (2) required.
      2) Nickel plated brass body with grid strainer, fits 3-1/2” opening, nickel plated brass 1-1/2” x 4” tailpiece.

5. Stops:
   b. Model: LFST09.
      1) 1/2” compression to 3/8” compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8” compression to 1/2” FIP, 12” length.

7. Accessories:
   a. Trap Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.
   b. Individual-Fixture, Water Tempering Valve:
      1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

V. S-8 – Single Compartment Sink: Drop-in stainless steel sink with chrome plated combination gooseneck and integrated emergency eyewash faucet with wrist blade handles. Solids interceptor trap drain. (Staff Areas).

1. Fixture:
   a. Manufacturer: Elkay.
      1) Alternates:
         a) Just.

2. Faucet:
   a. Manufacturer: Speakman.
   b. Model: SEF-1801.
1) With ASSE 1071 compliant thermostatic mixing valve installed below counter top.
2) Output temperature set to 90°F.
3) Lift top eyewash activation.
4) Check stops between mixing valve and angle stops and faucet.

3. Trap:
   a. Manufacturer: Zurn.
   b. Model: Z1180.
   1) Acid resistant solids interceptor for on floor mounting with removable sediment bucket.

4. Drain:
   a. Manufacturer: Elkay.
   1) Nickel plated brass body with grid strainer, fits 3-1/2” opening, nickel plated brass 1-1/2” x 4” tailpiece.

5. Stops:
   b. Model: LFST09.
   1) 1/2” compression to 3/8” compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
   1) Lead-free, stainless-steel braid, 3/8” compression to 1/2” FIP, 12” length.

7. Accessories:
   a. Trap Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.
   b. Individual-Fixture, Water Tempering Valve:
      1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

W. S-9 – Single Compartment Sink: Drop-in stainless steel sink with chrome plated combination gooseneck and integrated emergency eyewash faucet with wrist blade handles. (Staff Areas).

1. Fixture:
   a. Manufacturer: Elkay.
      1) Alternates:
         a) Just.

2. Faucet:
   a. Manufacturer: Speakman.
b. Model: SEF-1801.
   1) With ASSE 1071 compliant thermostatic mixing valve installed below counter top.
   2) Output temperature set to 90°F.
   3) Lift top eyewash activation.
   4) Check stops between mixing valve and angle stops and faucet.

3. Trap:
   a. 1-1/2” x 1-1/2” PVC p-trap with clean out plug.

4. Drain:
   a. Manufacturer: Elkay.
      1) Nickel plated brass body with grid strainer, fits 3-1/2” opening, nickel plated brass 1-1/2” x 4” tailpiece.

5. Stops:
   b. Model: LFST09.
      1) 1/2” compression to 3/8” compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8” compression to 1/2” FIP, 12” length.

7. Accessories:
   a. Trap Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.
   b. Individual-Fixture, Water Tempering Valve:
      1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

X. S-10 – Single Compartment Sink: Drop-in stainless steel sink deep bowl with chrome plated gooseneck with wrist blade handles. (Staff Areas).

1. Fixture:
   a. Manufacturer: Elkay.
      1) Alternates:
         a) Just.
2. Faucet:
   a. Manufacturer: Chicago Faucets.
      1) Alternates:
         a) T&S Brass.
      b. Model: 786-E35ABCP.
         1) Ceramic Cartridge.

3. Trap:
   a. 1-1/2" x 1-1/2" PVC p-trap with clean out plug.

4. Drain:
   a. Manufacturer: Elkay.
      1) Nickel plated brass body with grid strainer, fits 3-1/2" opening, nickel plated brass 1-1/2" x 4" tailpiece.

5. Stops:
   b. Model: LFST09.
      1) 1/2" compression to 3/8" compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8" compression to 1/2" FIP, 12" length.

7. Accessories:
   a. Trap Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.
   b. Individual-Fixture, Water Tempering Valve:
      1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

Y. S-11 – Single Compartment Sink:
   1. Fixture:
   2. Faucet:
      a. Manufacturer: Chicago Faucets.
         1) Alternates:
            a) T&S Brass.
3. Trap:
   a. 1-1/2" x 1-1/2" PVC p-trap with clean out plug.

4. Drain:
   a. Manufacturer: Elkay.
      1) Nickel plated brass body with grid strainer, fits 3-1/2" opening, nickel plated brass 1-1/2" x 4" tailpiece.

5. Stops:
   b. Model: LFST09.
      1) 1/2" compression to 3/8" compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8" compression to 1/2" FIP, 12" length.

7. Accessories:
   a. Trap Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.
   b. Individual-Fixture, Water Tempering Valve:
      1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

Z. S-12 – Single Compartment Sink: Integral Bowl by others with chrome plated gooseneck faucet with wrist blade handles and wall mounted swing down emergency eyewash.

1. Fixture:

2. Faucet:
   a. Manufacturer: Chicago Faucets.
      1) Alternates:
         a) T&S Brass.
      b. Model: 786-E35ABCP.
         1) Ceramic Cartridge.

3. Trap:
   a. 1-1/2" x 1-1/2" PVC p-trap with clean out plug.

4. Drain:
   a. Manufacturer: Elkay.
   1) Nickel plated brass body with grid strainer, fits 3-1/2" opening, nickel plated brass 1-1/2" x 4" tailpiece.

5. Stops:
   b. Model: LFST09.
      1) 1/2" compression to 3/8" compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8" compression to 1/2" FIP, 12" length.

7. Accessories:
   a. Individual-Fixture, Water Tempering Valve:
      1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.
   b. Swing Down Emergency Eyewash:
      1) Manufacturer: Bradley.
      2) Model: S19274HWB.
      3) Miscellaneous: With ASSE 1071 compliant, Bradley S19-2000 EFX8 thermostatic mixing valve, installed above ceiling, and output temperature set to 90°F.
      4) Provide swing check valves upstream of mixing valve.
   c. Trap Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.

AA. S-13 – Single Compartment Sink: Welcoming hand-washing station with two hydro flow recharging electronic faucets. (Public Handwashing)

1. Fixture:

2. Faucet:
   a. Manufacturer: Chicago Faucets.
      1) Alternates:
         a) T&S Brass.
   c. Miscellaneous: Quantity of two (2).

3. Trap:
   a. 1-1/2" x 1-1/2" PVC p-trap with clean out plug.

4. Drain:
a. Manufacturer: Elkay.
   1) Nickel plated brass body with grid strainer, fits 3-1/2” opening, nickel plated brass 1-1/2” x 4” tailpiece.

5. Stops:
b. Model: LFST09.
   1) 1/2” compression to 3/8” compression with wheel handle.

6. Supplies:
a. Manufacturer: Mainline.
b. Model: MLB112AF.
   1) Lead-free, stainless-steel braid, 3/8” compression to 1/2” FIP, 12” length.

7. Accessories:
a. Trap Wrap:
   1) Manufacturer: Proflow.
   2) Model: PF202WH.

b. Individual-Fixture, Water Tempering Valve:
   1) On hot water supply to each faucet provide and install ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

BB. S-14 – Single Compartment Sink:

1. Fixture:

2. Faucet:
a. Manufacturer: Chicago Faucets.
   1) Alternates:
      a) T&S Brass.
   c. Miscellaneous: Quantity of two (2).

3. Trap:
a. 1-1/2” x 1-1/2” PVC p-trap with clean out plug.

4. Drain:
a. Manufacturer: Elkay.

5. Stops:
b. Model: LFST09.
   1) 1/2” compression to 3/8” compression with wheel handle.
6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8” compression to 1/2” FIP, 12” length.

7. Accessories:
   a. Trap Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.
   b. Individual-Fixture, Water Tempering Valve:
      1) On hot water supply to each faucet provide and install ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

CC. S-15 – Single Compartment Sink:

1. Fixture:

2. Faucet:
   a. Manufacturer: Chicago Faucets.
      1) Alternates:
         a) T&S Brass.
       c. Miscellaneous: Quantity of two (2).

3. Trap:
   a. 1-1/2” x 1-1/2” PVC p-trap with clean out plug.

4. Drain:
   a. Manufacturer: Elkay.

5. Stops:
   b. Model: LFST09.
      1) 1/2” compression to 3/8” compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8” compression to 1/2” FIP, 12” length.

7. Accessories:
   a. Trap Wrap:
      1) Manufacturer: Proflow.
      2) Model: PF202WH.
b. **Individual-Fixture, Water Tempering Valve:**
   1) On hot water supply to each faucet provide and install ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

**DD.** Only provide lavatory with automatic sensor faucet where faucets with wrist blades are not permitted per WI SPS 382.50, Table 382.50-1.S-16 – Single Compartment Sink: Stainless steel sink drop-in with sensor activated chrome plated gooseneck faucet. (Nursing Department Isolation Patient Toilet Room, Nursery Infant Intensive Care Unit, Surgical Recovery Room, Clinical or Outpatient Department Dental Operating Room, Clinical or Outpatient Department Eye Exam Room, Clinical or Outpatient Department Ear, Nose, and Throat Exam Room).

1. **Fixture:**
   a. **Manufacturer:** Elkay.
      1) **Alternates:**
         a) Just.
   b. **Model:** LRAD1919.
      1) 6-1/2" deep bowl.

2. **Faucet:**
   a. **Manufacturer:** Chicago Faucets.
      1) **Alternates:**
         a) T&S Brass.
      b. **Model:** 116.933.AB.1.
         1) Ceramic Cartridge.

3. **Trap:**
   a. 1-1/2" x 1-1/2" PVC p-trap.

4. **Drain:**
   a. **Manufacturer:** Elkay.
   b. **Model:** LK-18.
      1) Nickel plated brass body with grid strainer, fits 3-1/2" opening, nickel plated brass 1-1/2" x 4" tailpiece.

5. **Stops:**
   a. **Manufacturer:** McGuire.
   b. **Model:** LFST09.
      1) 1/2" compression to 3/8" compression with wheel handle.

6. **Supplies:**
   a. **Manufacturer:** Mainline.
   b. **Model:** MLB112AF.
      1) Lead-free, stainless-steel braid, 3/8" compression to 1/2" FIP, 12" length.

7. **Accessories:**
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a. Trap Wrap:
   1) Manufacturer: Proflow.
   2) Model: PF202WH.

b. Individual-Fixture, Water Tempering Valve:
   1) ASSE 1070 compliant individual-fixture, water tempering valve, see specification section 221119.

EE. SS-1 – Service Sink: 14 GA type 304 stainless steel wall mounted sink with floor support and trap and rough chrome plated finish, wall mounted above backsplash faucet, with bucket hook.
1. Fixture:
   a. Manufacturer: Elkay.
   b. Model: ESSW2520C.

2. Faucet:
   a. Manufacturer: Elkay.
   b. Model: LK940C.

3. Trap:
   a. Manufacturer: Elkay.
      1) 3” Cast Iron with chrome plated, inside enameled finish with metal grid strainer.

4. Drain:
   a. Manufacturer: Elkay.
   b. Model: Integral.

5. Supplies:
   b. Model: LFST11.

FF. SSS-1 Surgical Scrub Sink: Single Station - Welded 16 GA stainless steel construction complete with washing compartment controls and mounting devices.
1. Fixture:
   a. Manufacturer: Steris.
   b. Model: 65109.000.

2. Faucet:
   a. Manufacturer: Steris.
   b. Model: Integral to unit.
      1) Gooseneck spout with rose spray head, with infrared sensor.
      2) Thermostatically controlled mixing valve to a maximum of 115°F degrees.

3. Trap:
   a. Manufacturer: Steris.
   b. Model: Integral to unit.
      1) 1-1/2” OD drain outlet.
4. Accessories:
   a. Carrier:
      1) Manufacturer: Steris.
      2) Model: Supplied with unit, conforms to ANSI A112.6.1M type III with heavy steel stanchions and supporting plates with cast iron feet.
   b. Soap Dispensing:
      1) Manufacturer: Steris.
      2) Model: Integral to unit.
      a) Soap is dispensed via a Knee operator. Soap shall dispense approximately 2 cc of soap and is pumped out pushing in the panel and releasing the knee operator.

5. Stops:
      1) 1/2” compression to 1/2” compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB812AF.
      1) Lead-free, stainless-steel braid, 1/2” compression to 1/2” FIP, 12” length.

7. Electrical: 120v, 60 Hz, 1 amp.

GG. SSS-2 Surgical Scrub Sink: Dual Station - Welded 16 GA stainless steel construction complete with washing compartment controls and mounting devices

1. Fixture:
   a. Manufacturer: Steris.
   b. Model: 071655-000.

2. Faucet:
   a. Manufacturer: Steris.
   b. Model: Integral to unit.
      1) Two (2) gooseneck spouts with rose spray head, with infrared sensor.
      2) Thermostatically controlled mixing valve to a maximum of 115°F degrees.

3. Trap:
   a. Manufacturer: Steris.
   b. Model: Integral to unit.
      1) Two (2) 1-1/2” OD drain outlets.

4. Accessories:
   a. Carrier:
      1) Manufacturer: Steris.
      2) Model: Supplied with unit, conforms to ANSI A112.6.1M type III with heavy steel stanchions and supporting plates with cast iron feet.
b. Soap Dispensing:
   1) Manufacturer: Steris.
   2) Model: Integral to unit. Two (2) operators, one per station.
      a) Soap is dispensed via a Knee operator. Soap shall dispense
         approximately 2 cc of soap and is pumped out pushing in the panel
         and releasing the knee operator.

5. Stops:
      1) Two (2) sets required.
      2) 1/2" compression to 1/2" compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB812AF.
      1) Two (2) sets required.
      2) Lead-free, stainless-steel braid, 1/2" compression to 1/2" FIP, 12" length.

7. Electrical: 120v, 60 Hz, 1 amp.

HH. SSS-3 Surgical Scrub Sink: Triple Station - Welded 16 GA stainless steel construction complete
   with washing compartment controls and mounting devices.

1. Fixture:
   a. Manufacturer: Steris.
   b. Model: 071656-000.

2. Faucet:
   a. Manufacturer: Steris.
   b. Model: Integral to unit.
      1) Three (3) gooseneck spout with rose spray head, with infrared sensor.
      2) Thermostatically controlled mixing valve to a maximum of 115°F degrees.

3. Trap:
   a. Manufacturer: Steris.
   b. Model: Integral to unit.
      1) Three (3) 1-1/2" OD drain outlets.

4. Accessories:
   a. Carrier:
      1) Manufacturer: Steris.
      2) Model: Supplied with unit, conforms to ANSI A112.6.1M type III with heavy
         steel stanchions and supporting plates with cast iron feet.

   b. Soap Dispensing:
      1) Manufacturer: Steris.
      2) Model: Integral to unit. Three (3) operators, one per station.
a) Soap is dispensed via a Knee operator. Soap shall dispense approximately 2 cc of soap and is pumped out pushing in the panel and releasing the knee operator.

5. Stops:
      1) Three (3) sets required.
      2) 1/2” compression to 1/2” compression with wheel handle.

6. Supplies:
   a. Manufacturer: Mainline.
   b. Model: MLB812AF.
      1) Three (3) sets required.
      2) Lead-free, stainless-steel braid, 1/2” compression to 1/2” FIP, 12” length.

7. Electrical: 120v, 60 Hz, 1 amp.

II. CSS-1 – Clinical Service Sink: Wall hung vitreous china flushing rim also known as a “Hopper”.

1. Fixture:
   a. Manufacturer: Kohler.
      1) Alternates:
         a) Zurn.
      1) 1-1/2 inch brass Top Spud.

2. Faucet:
   a. Manufacturer: Zurn.
   b. Model: Z842D6-LSI-LVB-PE-2XT.
      1) Chrome plated cast brass 8” faucet with quarter turn wrist blade handles.

3. Flush Valve:
   a. Manufacturer: Zurn.
   b. Model: Z6017AV.
      1) 24” rough inch exposed height flush valve.

   a. Manufacturer: Zurn.
      1) Wall mounted chrome plated self-closing double pedal mixing valve.
      2) Spray hose with insulated handle and hook.
      3) Elevated vacuum breaker.

5. Accessories:
   a. Rim Guard:
      1) Manufacturer: Kohler.
2) Model: K-8935.

b. Foot Pedal:
   1) Manufacturer: Zurn.
   2) Model: Z85500-WM.

JJ. MB-1 – Mop Basin: Floor mounted, one piece, 36” x 36” terrazzo mop basin with 12” high walls.

1. Fixture:
   a. Manufacturer: Fiat.
   b. Model: TSB 500.

2. Faucet:
   a. Manufacturer: Chicago Faucets.
      1) Alternates:
         a) T&S Brass.

3. Accessories:
   a. Hose and Hose Bracket:
      1) Manufacturer: Fiat.
      2) Model: 832AA.
         a) Install at same elevation as faucet to left of Hot water side of faucet.
      b. Aluminum Bumper Guard with Vinyl Insert:
         1) Manufacturer: Fiat.
         2) Model: 1239BB.
         a) Install on non-wall sides.
   c. Silicone Sealant:
      1) Manufacturer: Fiat.
      2) Model: 833AA.
         a) Seal all sides in contact with walls and or floors.
   d. Wall Guards:
      1) Manufacturer: Fiat.
      2) Model: MSG.
   e. Mop hanger
      1) Manufacturer: Fiat.
      2) Model: 889-CC.
         a) 3” wide stainless steel with (3) rubber tool grips.
   f. Accessories
      1) Hose Bib.
a) Install (1) non potable cold water hose bib (HB-1) with threaded on vacuum breaker at the same elevation to the right of the cold water side of the faucet. This is for the Environmental Services (EVS) to connect the soap system.

b) Provide a sign above hose bib See Specifications Section 220553.

KK. SH-1 – Shower: Shower base for transfer shower solid surface with center drain and faucet. Walls of shower by others.

1. Basin:
   a. Manufacturer: Swanstone.
      1) Alternates:
         a) Best Bath.
   b. Model: STF-3838.

2. Valve:
   a. Manufacturer: Symmons.
   b. Model: 9605-PLR. Pressure Balancing shower system.
      1) 1.5 GPM flow restrictor.
      2) Integral stops.
      3) Integral check stops.
      4) REV – reverse coring for back to back installations.
      5) 6-foot hose.
      6) Standard 36” grab bar for hand held shower.
      7) Diverter.

3. Head:
   a. Manufacturer: Symmons.
   b. Model: Included with model.

LL. SH-2 – Shower:

1. Basin:
   a. Manufacturer: Swanstone.
      1) Alternates:
         a) Best Bath.
   b. Model: STF-3838.

2. Valve & Hand shower & Head:
   a. Manufacturer: Moen.

MM. SH-3 – Shower:

1. Basin:

2. Valve & Hand shower:
a. Manufacturer: Moen.

3. Head:
   a. Manufacturer: Moen.
   b. Model: TS312.

NN. DB-1 Dialysis Box:
1. Fixture:
   a. Manufacturer: Bradley.

OO. EWC-1 – Electric Water Cooler: Single station bubbler, wall mounted with the finish to be light grey granite and 120 volt plug in compressor. Barrier free design.
1. Fixture:
   a. Manufacturer: Elkay.

2. Trap:
   b. Model: B8872.

3. Supplies:
   b. Model: H2165CC.

PP. EWC-2 – Electric Water Cooler: Dual station high low bubblers with bottle filler mounted on the upper unit that is wall mounted with the finish to be light grey granite and 120-volt plug in compressor. Single water supply and single drain connections. Barrier free design.
1. Fixture:
   a. Manufacturer: Elkay.
   b. Model: LZS8WS.

2. Trap:
   b. Model: B8872.

3. Supplies:
   b. Model: H2165CC.

QQ. EEW-1 – Emergency Eyewash: Wall mounted dual handle with stainless steel bowl tail piece and p-trap. Barrier free design.
1. Fixture:
   a. Manufacturer: Bradley.
   b. Model: S19224BPT.

2. Thermostatic mixing valve: with check stops and thermometer.
   a. Manufacturer: Bradley.
   1) Install thermostatic mixing valve above ceiling.
   2) Set output temperature to be 90°F.
   3) Install check valves on inlet side of mixing valve.

RR. HB-1 – Hose Bibb: Interior locations of single temperature bibb with threads for vacuum breaker. Chrome finish for wash down purposes.
   1. Fixture:
      a. Manufacturer: Woodford.
      c. Watts 8A threaded on vacuum breaker.

SS. HB-2 – Hot & Cold Wall Faucet: Interior locations with dual temperature control chrome finish for wash down purposes where other than cold water is required such as loading docks.
   1. Fixture:
      a. Manufacturer: Chicago Faucets.
      b. Model: 835-RCF. With integral vacuum breaker and male threaded outlet.

TT. WH-1 – Non-Freeze Wall Hydrant
   1. Fixture:
      a. Manufacturer: Woodford.
         1) Chrome plated with loose key.
         2) Vacuum breaker with ¾” male hose threading.

UU. RH-1 – Non-Freeze Roof Hydrant:
   1. Fixture:
      a. Manufacturer: Woodford.
      b. Model: SRH-MS.
         1) No drain required roof hydrant.

VV. WOB-1 – Single Wall Outlet Box: Recess into wall with angle stop for protection. Installation below counter or in the back of cabinets.
   1. Fixture:
      a. Manufacturer: Sioux Chief.
      b. Model: 696-G1010MR.
         1) Single outlet for coffee maker or icemaker in refrigerator with water hammer arrestor in box.

WW. WOB-2 – Double Wall Outlet Box: Recess into wall with angle stop for protection. Installation below counter or in the back of cabinets.
   1. Fixture:
      a. Manufacturer: Sioux Chief.
      b. Model: 696-G2001MF.
         1) Double water outlet for two coffee makers or coffee maker and refrigerator icemaker with two water hammer arrestors in the box (no drain).
XX. WOB-3 – Double Wall Outlet and Drain Box: Recess into wall with angle stop for protection. Installation below counter or in the back of cabinets.
   1. Fixture:
      a. Manufacturer: Sioux Chief.
      b. Model: 696-2313WR.
      1) Double water outlet for two coffee makers or coffee maker and icemaker with drain requirement with two water hammer arrestors in the box. Drain is in a separate box that can be placed in different location or next to the supply box. Drain may only receive discharge from clothes washer machine.

YY. WOB-4 – Double Wall Outlet Box and drain in same box.
   1. Fixture:
      a. Manufacturer: Sioux Chief.
      b. Model: 696-2403CR.
      1) Top feed for water connection with the water hammer arrestors being placed in the ceiling space above. Drain is located in the same box. Drain may only receive discharge from clothes washer machine.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.
   B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.
   C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
   A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturer's written instructions.
   B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
      1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
      2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
      3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
   C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.
   D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.
   E. Install wall-mounting fixtures with tubular waste piping attached to supports.
   F. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.
   G. Install counter-mounting fixtures in and attached to casework.
   H. Install fixtures level and plumb according to roughing-in drawings.
I. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

K. Install trap wrap on any sink or lavatory fixture with an exposed trap.

L. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

M. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

N. Install toilet seats on water closets.

O. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

P. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

Q. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

R. Install ASSE 1070 compliant individual-fixture, water tempering valve on hot water supply to handwashing faucets.

S. Install shower flow-control fittings with specified maximum flow rates in shower arms.

T. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.

2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

U. Install escutcheons on piping at wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Basic Division 22 Requirements."

V. Set shower receptors and service basins in leveling bed of cement grout. Grout is specified in Division 22 Section "Basic Division 22 Requirements."

W. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

X. Wall mounted fixtures shall be mounted so as not to be able to pull out from wall. Use backing plates to bolt to.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding."
D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL
A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.
D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.
E. Install fresh batteries in sensor-operated mechanisms.
F. Test all eyewashes prior to turning over fixtures to owner make any adjustments as required for proper flow and temperature. Retest and record date of test. The owner must maintain ANSI Standards.

3.5 ADJUSTING
A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
B. Operate and adjust controls. Replace damaged and malfunctioning controls.
C. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.
D. Replace washers and seals of leaking and dripping faucets and stops.
E. Install fresh batteries in sensor-operated mechanisms.

3.6 CLEANING
A. Clean fixtures, faucets, and other fittings with manufacturers’ recommended cleaning methods and materials. Do the following:
   1. REMOVE faucet spouts and screens and strainers, remove sediment and debris by properly flushing the entire system, and reinstall screens, strainers and spouts.
   2. Remove sediment and debris from drains.
B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION
A. Provide protective covering for installed fixtures and fittings.
B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.
C. Protect all fixtures from damage during construction up to turn over to owner.

END OF SECTION 224000
SECTION 226113 – MEDICAL COMPRESSED-AIR PIPING

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following:
   1. Medical air piping and specialties, that are designated "medical air," operating at 50 to 55 psig.
B. Related Sections include the following:
   1. Division 12 Section "Healthcare Casework" for compressed-air outlets in medical casework.
   2. Division 22 Section "Compressed-Air Equipment for Healthcare Facilities" for medical air compressors.

1.2 DEFINITIONS
A. D.I.S.S.: Diameter-index safety system.
B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
C. Medical Compressed-Air Piping Systems: Include medical air piping systems.

1.3 SUBMITTALS
A. Product Data: For the following:
   1. Compressed-air tubes and fittings.
   2. Compressed-air valves and valve boxes.
   3. Medical compressed-air service connections.
   4. Medical compressed-air pressure control panels.
   5. Medical compressed-air manifolds.
   6. Medical compressed-air alarm system components.
B. Shop Drawings: Diagram power, signal, and control wiring.
C. Piping Material Certification: Signed by Installer certifying that medical compressed-air piping materials comply with NFPA 99 requirements.
D. Qualification Data: For Installer and testing agency.
E. Brazing certificates.
F. Field quality-control test reports.
G. Operation and Maintenance Data: For compressed-air piping specialties to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE
A. Installer Qualifications:
   1. Medical Compressed-Air Piping Systems for Healthcare Facilities: Qualify installers according to ASSE Standard #6010.
B. Testing Agency Qualifications: An independent testing agency, approved by the Owner, with the experience and capability to conduct the medical air piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization, National Inspection Testing Certification (NITC) or is a Nationally Recognized Testing Laboratory (NRTL), and that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel according to ASSE Standard #6020 for inspectors and ASSE Standard #6030 for verifiers.

C. Source Limitations: Obtain compressed-air service connections of same type and from same manufacturer as service connections provided for in Division 22 Section "Gas Piping for Healthcare Facilities."


E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


1.5 PROJECT CONDITIONS

A. Interruption of Existing Medical Compressed-Air Service(s): Do not interrupt medical compressed-air service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Architect, Construction Manager and Owner no fewer than seven days in advance of proposed interruption of medical compressed-air service(s).

2. Do not proceed with interruption of medical compressed-air service(s) without Architect, Construction Manager and Owner written permission.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate medical compressed-air service connections with other service connections. Medical vacuum service connections are specified in Division 22 Section "Vacuum Piping for Healthcare Facilities," and medical gas service connections are specified in Division 22 Section "Gas Piping for Healthcare Facilities."

1.7 EXTRA MATERIALS

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: Per the manufacturer listed.

B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.
2.2 PIPES, TUBES, AND FITTINGS

A. Copper Medical Gas Tube: ASTM B 819, Type L, seamless, drawn temper, that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in blue for Type L tube.
   1. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
   2. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.

B. Memory-Metal Couplings: Cryogenic compression fitting made of ASTM F 2063, nickel-titanium, shape-memory alloy, and that has been manufacturer cleaned, purged, and sealed for oxygen service according to CGA G-4.1.
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Smart Technology, Inc.

C. Copper Water Tube: ASTM B 88, Type M, seamless, drawn temper.

2.3 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

B. Threaded-Joint Tape: PTFE.

2.4 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.

B. Ball Valves: MSS SP-110, 3-piece body, brass or bronze.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      c. Amico Corporation.
      d. BeaconMedaes.
      e. Conbraco Industries, Inc.
      f. NIBCO INC.
      g. Squire-Cogswell/Aeros Instruments, Inc.
      h. Tri-Tech Medical.
      i. Or approved equal.
   2. Pressure Rating: 300 psig (2070 kPa) minimum.
   3. Ball: Quarter turn full-port, dual port, chrome-plated brass.
4. Seats: PTFE or TFE.
5. Handle: Lever type with locking device.
6. Stem: Blowout proof with PTFE or TFE seal.

C. Check Valves: In-line pattern, bronze.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Amico Corporation.
      c. BeaconMedeas.
      d. Conbraco Industries, Inc.
      e. Squire-Cogswell/Aeros Instruments, Inc.
      f. Tri-Tech Medical.
   2. Pressure Rating: 300 psig minimum.

D. Zone Valves: MSS SP-110, 3-piece-body, brass or bronze ball valve with gage.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      c. Amico Corporation.
      d. BeaconMedeas.
      e. Squire-Cogswell/Aeros Instruments, Inc.
      f. Tri-Tech Medical.
   2. Pressure Rating: 300 psig (2070 kPa) minimum.
   4. Seats: PTFE or TFE.
   5. Handle: Lever.
   6. Stem: Blowout proof with PTFE or TFE seal.
   8. Pressure Gage: Manufacturer installed on one copper-tube extension.

E. Zone Valve Boxes: Formed steel with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      c. Amico Corporation.
      d. BeaconMedeas.
      e. Squire-Cogswell/Aeros Instruments, Inc.
   2. Interior Finish: Factory-applied white enamel.
   3. Cover Plate: Aluminum or extruded-anodized aluminum with frangible or removable windows.
4. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms and/or areas served, according to NFPA 99.

F. Zone Valve Boxes: Formed or extruded aluminum with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Tri-Tech Medical.
   2. Interior Finish: Factory-applied white enamel.
   3. Cover Plate: Aluminum or extruded-anodized aluminum with frangible or removable windows.
   4. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99. See Section 220553 “Identification for Plumbing Piping and Equipment.”

G. Safety Valves: Bronze-body, ASME-construction, poppet, pressure-relief type with settings to match system requirements.

H. Pressure Regulators: Bronze body and trim; spring-loaded, diaphragm-operated relieving type; manual pressure-setting adjustment; rated for 250-psig minimum inlet pressure; and capable of controlling delivered air pressure within 0.5 psig for each 10-psig inlet pressure.

I. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig minimum working pressure, capable of automatic discharge of collected condensate. Include mounting bracket where wall mounting is indicated.

2.5 MEDICAL COMPRESSED-AIR OUTLET CONNECTIONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Amico Corporation.
   5. Squire-Cogswell/Aeros Instruments, Inc.
   6. Tri-Tech Medical.
   7. Any code compliant manufacturers.

B. Connection Devices: For specific medical compressed-air pressure and service listed. Include roughing-in assemblies, finishing assemblies, and cover plates. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate. Furnish recessed-type units made for concealed piping unless otherwise indicated.
   1. Roughing-in Assembly:
      a. Steel outlet box for recessed mounting and concealed piping.
      b. Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed.
      c. Double seals that will prevent air leakage.
      d. ASTM B 819, NPS 3/8 copper outlet tube brazed to valve with service marking and tube-end dust cap.
   2. Finishing Assembly:
a. Brass housing with primary check valve.
b. Double seals that will prevent air leakage.
c. Cover plate with gas-service label.

3. Quick-Coupler Service Connections: Pressure outlet with noninterchangeable keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use.

4. D.I.S.S. Service Connections: Pressure outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.

5. Cover Plates: One piece, anodized aluminum and permanent, color-coded, identifying label matching corresponding service.

6. Outlets to be placed in an MRI room shall be constructed of non-metallic parts.

2.6 MEDICAL COMPRESSED-AIR-PIPING ALARM SYSTEMS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   3. Amico Corporation.
   5. Squire-Cogswell/Aeros Instruments, Inc.
   6. Tri-Tech Medical.

D. Panels for medical compressed-air piping systems may be combined in single panels with medical vacuum and medical gas piping systems.

E. Components: Designed for continuous service and to operate on power supplied from [120], [240] [277]-V ac power source to alarm panels and with connections for low-voltage wiring to remote sensing devices. Include step-down transformers if required.

F. Dew Point Monitors: Continuous line monitoring, having panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, factory- or field-installed valved bypass, and visual and cancelable audio signal for dryer site and master alarm panels. Alarm signals when pressure dew point rises above 39° F at 55 psig.

G. Pressure Switches or Transducer Sensors: Continuous line monitoring with electrical connections for alarm system. Transducers are to be placed in accessible area for maintenance purposes.
   1. Low-Pressure Operating Range: 0- to 100-psig.
   2. High-Pressure Operating Range: Up to 250-psig.
H. Carbon Monoxide Monitors: Panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, and factory- or field-installed valved bypass. Alarm signals when carbon monoxide level rises above 10 ppm.

I. General Requirements for Medical Compressed-Air Alarm Panels: Factory wired with audible and color-coded visible signals to indicate specified functions.
   1. Mounting: Recessed installation.
   2. Enclosures: Fabricated from minimum 0.047-inch-thick steel or minimum 0.05-inch-thick aluminum, with knockouts for electrical and piping connections.

J. Master Alarm Panels: Separate trouble alarm signals, pressure gages, and indicators for medical compressed-air piping systems.
   1. Include alarm signals when the following conditions exist:
      a. Medical Air: Pressure drops below 40 psig +/- 20%, backup air compressor is in operation, pressure drop across filter assembly increases more than 2 psig (13.8 kPa), dew point rises above 35 deg F at 55 psig, carbon monoxide level rises above 10 ppm, and high water level is reached in receiver for liquid-ring, medical air compressor systems.

K. Anesthetizing-Area Alarm Panels: Separate trouble alarm signals, pressure gages, and indicators for medical compressed-air piping systems.
   1. Include alarm signals when the following conditions exist:
      a. Medical Air: Pressure drops below 40 psig or rises above 60 psig +/- 20%.

L. Area Alarm Panels: Separate trouble alarm signals, pressure gages, and indicators for medical compressed-air piping systems.
   1. Include alarm signals when the following condition exists:
      a. Medical Air: Pressure drops below 40 psig or rises above 60 psig

2.7 COMPUTER INTERFACE CABINET

A. Description: Wall-mounting, welded-steel control cabinet with gasketed door, mounting brackets, grounding device, and white-enamel finish for connection of medical compressed-air-piping-system alarms to facility computer. Include factory-installed signal circuit boards, power transformer, circuit breaker, wiring terminal board, and internal wiring capable of interfacing 20 alarm signals.

2.8 COMPRESSED-AIR-CYLINDER STORAGE RACKS

A. Wall Storage Racks: Fabricate racks with chain restraints for upright cylinders as indicated or provide equivalent manufactured wall racks.

B. Freestanding Storage Racks: Fabricate racks as indicated or provide equivalent manufactured storage racks.

C. Individual chaining on in-service tanks, group chaining on tanks not in service.

2.9 FLEXIBLE PIPE CONNECTORS

A. Manufacturers: Subject to compliance with NFPA 99 requirements 5.1.10.11.6, provide approved products by one of the following:
   1. Flex-Hose Co., Inc.
2. Flexicraft Industries.
3. Hyspan Precision Products, Inc.
5. Metraflex, Inc.
6. Proco Products, Inc.
7. Unaflex.
8. Universal Metal Hose; a Hyspan Co.
9. Burst Pressure shall be per NFPA 99.

B. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   2. End Connections: Threaded copper pipe or plain-end copper tube.
   3. Burst Pressure shall be per NFPA 99.

2.10 NITROGEN
A. Description: Comply with USP 28 - NF 23 for oil-free dry nitrogen.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS
A. Connect new tubing to existing tubing with memory-metal couplings.
B. Medical Air Piping: Use Type L copper medical gas tube; wrought-copper fittings; and brazed joints.
C. Medical Air Piping: Use Type K copper piping for underground piping.
D. Drain Piping: Use the following piping materials:
   1. Copper water tube, cast- or wrought-copper fittings, and soldered joints.

3.2 PIPING INSTALLATION
A. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
B. Comply with ASSE Standard #6010 for installation of compressed-air piping.
C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
F. Install piping adjacent to equipment and specialties to allow service and maintenance.
G. Install air and drain piping with 1 percent slope downward in direction of flow.
H. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications below unless otherwise indicated.
I. Install eccentric reducers, if available, where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
J. Install branch connections to compressed-air mains from top of main per NFPA 99 1999. Provide drain leg and drain trap at end of each main and branch and at low points.
K. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping."
L. Install piping to permit valve servicing.
M. Install piping free of sags and bends.
N. Install fittings for changes in direction and branch connections.
O. Install medical compressed-air piping to medical compressed-air service connections specified in this Section, to medical compressed-air service connections in equipment specified in Division 22 Section "Gas Piping for Laboratory and Healthcare Facilities," and to equipment specified in other Sections requiring medical compressed-air service.
P. Install compressed-air service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.
Q. Connect compressed-air piping to air compressors and to compressed-air outlets and equipment requiring compressed-air service.
R. Install unions in copper compressed-air tubing downstream of service valves and at final connection to each piece of equipment, machine, and specialty.
S. Install sleeves for piping penetrations of walls, ceilings and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."
T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Basic Division 22 Requirements."
U. Install escutcheons for piping penetrations of walls, ceilings and floors. Comply with requirements for escutcheons specified in Division 22 Section "Basic Division 22 Requirements."

3.3 VALVE INSTALLATION

A. Install shutoff valve at each connection to and from compressed-air equipment and specialties.
B. Install check valves to maintain correct direction of compressed-air flow from compressed-air equipment.
C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.
D. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.
E. Install safety valves on compressed-air receivers where required by NFPA 99 and where recommended by specialty manufacturers.
F. Install automatic drain valves on equipment, specialties, and piping with drain connection. Run drain piping to floor drain so contents spill over or into it.

G. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter of each air compressor.

3.4 JOINT CONSTRUCTION

A. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

B. Threaded Joints: Apply appropriate tape to external pipe threads.

C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free dry nitrogen during brazing.

D. Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of memory-metal coupling joints.

3.5 COMPRESSED-AIR SERVICE COMPONENT INSTALLATION

A. Install compressed-air pressure control panel in walls. Attach to substrate.

B. Install compressed-air manifolds anchored to substrate.

C. Install compressed-air cylinders and connect to manifold piping.

D. Install compressed-air manifolds with seismic restraints as indicated.

E. Install compressed-air-cylinder wall storage racks attached to substrate.

F. Install a Medical Compressed Air system on a concrete base and connect top the medical air distribution system after the final source equipment regulators.

3.6 MEDICAL COMPRESSED-AIR-PIPING ALARM SYSTEM INSTALLATION

A. Alarm panels for medical compressed-air piping systems may be combined in single panels with medical vacuum piping systems and medical gas piping systems.

B. Install alarm system components for medical compressed-air-piping according to and in locations required by NFPA 99.

C. Install area and master alarm panels for medical compressed-air-piping system where indicated.

D. Install computer interface cabinet with connection to medical compressed-air-piping alarm system and to facility computer.

3.7 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

3.8 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for medical compressed-air piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment."
FIELD QUALITY CONTROL FOR MEDICAL COMpressed-AIR PIPING IN HEALTHCARE FACILITIES

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections of medical compressed-air piping in healthcare facilities and prepare test reports.

B. Perform tests and inspections of medical compressed-air piping systems in healthcare facilities and prepare test reports.

C. Tests and Inspections:
   1. Medical Compressed-Air Testing Coordination: Perform tests, inspections, verifications, and certification of medical compressed-air piping systems concurrently with tests, inspections, and certification of medical vacuum piping and medical gas piping systems.
   2. Preparation: Perform the following Installer tests according to requirements in NFPA 99 authority having jurisdiction and ASSE Standard #6010:
      a. Initial blowdown.
      b. Initial pressure test.
      c. Cross-connection test.
      d. Piping purge test.
      e. Standing pressure test for positive-pressure medical compressed-air piping.
      f. Repair leaks and retest until no leaks exist.
   3. System Verification: Comply with requirements in NFPA 99, ASSE Standard #6020, and ASSE Standard #6030 for verification of medical compressed-air piping systems and perform the following tests and inspections:
      a. Standing pressure test.
      b. Individual-pressurization cross-connection test.
      c. Valve test.
      d. Master and area alarm tests.
      e. Piping purge test.
      f. Piping particulate test.
      g. Piping purity test.
      h. Final tie-in test.
      i. Operational pressure test.
      j. Medical air purity test.
      k. Verify correct labeling of equipment and components.
   4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
      a. Inspections performed.
      b. Procedures, materials, and gases used.
      c. Test methods used.
      d. Results of tests.

D. Remove and replace components that do not pass tests and inspections and retest as specified above.

DEMONSTRATION

A. Engage factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain medical compressed-air alarm systems. Refer to Division 01 Section "Demonstration and Training."

MEDICAL COMPRESSED AIR PIPING
3.11 ASSET TAGGING

A. Laboratory piping contractor will be responsible to obtain and for the placing and recording all asset tags on all relevant assets installed.

END OF SECTION 226113
SECTION 226115 - COMPRESSED-AIR PIPING FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following:
   1. Compressed-air piping and specialties for nonmedical laboratory facilities, designated "laboratory air," operating and generating at at 100 psig
B. Related Sections include the following:
   1. Division 11 Section "Laboratory Fume Hoods" for compressed-air outlets in laboratory fume hoods.
   2. Division 12 Section "Laboratory Casework" for compressed-air outlets in casework.
   3. Division 22 Section "General-Service Compressed-Air Piping" for general-service compressed-air piping.
   4. Division 22 Section "Compressed-Air Equipment for Laboratory Facilities" for laboratory air compressors.

1.2 DEFINITIONS
A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.3 SUBMITTALS
A. Product Data: For the following:
   1. Compressed-air tubes and fittings.
   2. Compressed-air valves and valve boxes.
   3. Compressed-air outlets, connections and regulators
B. Shop Drawings: Diagram power, signal, and control wiring.
C. Piping Material Certification: Signed by Installer certifying that medical compressed-air piping materials comply with NFPA 99 requirements.
D. Qualification Data: For Installer and testing agency.
E. Brazing certificates.
F. Field quality-control test reports.
G. Operation and Maintenance Data: For compressed-air piping specialties to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE
A. Installer Qualifications:
   1. Compressed-Air Piping Systems for Healthcare Facilities: Qualify installers according to ASSE Standard #6010.
B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is a Nationally Recognized Testing Laboratory (NRTL), and that is acceptable to authorities having jurisdiction.
1. Qualify testing personnel according to ASSE Standard #6020 for inspectors and ASSE Standard #6030 for verifiers.

C. Source Limitations: Obtain compressed-air service connections of same type and from same manufacturer as service connections provided for in Division 22 Section "Gas Piping for Laboratory Facilities." The Laboratory compressed air system cannot connect to a Medical Compressed Air system.


E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. ASME Compliance:
   1. Comply with ASME B31.9, "Building Services Piping," for laboratory compressed-air piping operating at 150 psig or less.

1.5 PROJECT CONDITIONS
A. Interruption of Existing Laboratory Compressed-Air Service(s): Do not interrupt laboratory compressed-air service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Architect, Construction Manager and Owner no fewer than five days in advance of proposed interruption of laboratory compressed-air service(s).
   2. Do not proceed with interruption of laboratory compressed-air service(s) without Architect, Construction Manager and Owner written permission.

1.6 COORDINATION
A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate compressed-air service connections with other service connections. Vacuum service connections are specified in Division 22 Section "Vacuum Piping for Laboratory Facilities," and I gas service connections are specified in Division 22 Section "Gas Piping for Laboratory Facilities."

1.7 EXTRA MATERIALS
A. Provide 5% of the installed components as extra products for the future use by the Owner. This includes regulators, valves, outlets, etc.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Basis of Design: Per the manufacturer listed.

B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.
2.2 PIPES, TUBES, AND FITTINGS

A. Copper Medical Gas Tube: ASTM B 819, Type L, seamless, drawn temper, that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and in blue for Type L tube.

1. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
2. Wrought-Copper Fittings: ASME B16.22, solder-join pressure type or MSS SP-73, with dimensions for brazed joints.
3. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.

B. Memory-Metal Couplings: Cryogenic compression fitting made of ASTM F 2063, nickel-titanium, shape-memory alloy, and that has been manufacturer cleaned, purged, and sealed for oxygen service according to CGA G-4.1.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Smart Technology, Inc.

C. Copper Water Tube: ASTM B 88, Type L, seamless, drawn temper.


2.3 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.4 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.

B. Ball Valves: MSS SP-110, 3-piece body, brass or bronze.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Amico Corporation.
   d. BeaconMedaes.
   e. Conbraco Industries, Inc.
   f. NIBCO INC.
   g. Squire-Cogswell/Aeros Instruments, Inc.
   h. Tri-Tech Medical.
   i. Or approved equal.

2. Pressure Rating: 300 psig (2070 kPa) minimum.
4. Seats: PTFE or TFE.
5. Handle: Lever type with locking device.
6. Stem: Blowout proof with PTFE or TFE seal.

C. Check Valves: In-line pattern, bronze.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Amico Corporation.
   c. BeaconMedaes.
   d. Conbraco Industries, Inc.
   e. Squire-Cogswell/Aeros Instruments, Inc.
   f. Tri-Tech Medical.
2. Pressure Rating: 300 psig minimum.

D. Zone Valves: MSS SP-110, 3-piece-body, brass or bronze ball valve with gage.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Amico Corporation.
   d. BeaconMedaes.
   e. Squire-Cogswell/Aeros Instruments, Inc.
   f. Tri-Tech Medical.
2. Pressure Rating: 300 psig (2070 kPa) minimum.
4. Seats: PTFE or TFE.
5. Handle: Lever.
6. Stem: Blowout proof with PTFE or TFE seal.
8. Pressure Gage: Manufacturer installed on one copper-tube extension.
9. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Tri-Tech Medical.
10. Interior Finish: Factory-applied white enamel.
11. Cover Plate: Aluminum or extruded-anodized aluminum with frangible or removable windows.
12. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

E. Safety Valves: Bronze-body, ASME-construction, poppet, pressure-relief type with settings to match system requirements.

F. Pressure Regulators: Bronze body and trim; spring-loaded, diaphragm-operated relieving type; manual pressure-setting adjustment; rated for 250-psig minimum inlet pressure; and capable of controlling delivered air pressure within 0.5 psig for each 10-psig inlet pressure.
G. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig minimum working pressure, capable of automatic discharge of collected condensate.

2.5 FLEXIBLE PIPE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Flex-Hose Co., Inc.
   2. Flexicraft Industries.
   3. Hyspan Precision Products, Inc.
   5. Metraflex, Inc.
   6. Proco Products, Inc.
   7. Unaflex.
   8. Universal Metal Hose; a Hyspan Co.

B. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   2. End Connections: Threaded copper pipe or plain-end copper tube.

2.6 NITROGEN

A. Description: Comply with USP 28 - NF 23 for oil-free dry nitrogen.

PART 3 - EXECUTION

3.1 PREPARATION

3.2 PIPING APPLICATIONS

A. Connect new tubing to existing tubing with memory-metal couplings.

B. Laboratory Air Piping: Use the following piping materials for each size range:
   1. NPS 4 and Smaller: Type L, copper tube; wrought-copper fittings; and brazed joints. Type K copper piping for underground piping.

C. Medical Laboratory Air Piping: Use Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.

D. Drain Piping: Use the following piping materials:
   1. Copper water tube, cast- or wrought-copper fittings, and soldered joints.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Comply with ASSE Standard #6010 for installation of compressed-air piping.

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.

F. Install piping adjacent to equipment and specialties to allow service and maintenance.

G. Install air and drain piping with 1 percent slope downward in direction of flow.

H. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications below unless otherwise indicated.

I. Install eccentric reducers, if available, where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

J. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.

K. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping."

L. Install piping to permit valve servicing.

M. Install piping free of sags and bends.

N. Install fittings for changes in direction and branch connections.

O. Install Laboratory compressed-air piping to Laboratory compressed-air service connections specified in this Section, to laboratory compressed-air service connections in equipment specified in Division 22 Section "Gas Piping for Laboratory Facilities," and to equipment specified in other Sections requiring medical compressed-air service.

P. Install compressed-air service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly. Provide a quick-connect fitting unless directed otherwise by the Owner or additional information in the contract documents.

Q. Connect compressed-air piping to air compressors and to compressed-air outlets and equipment requiring compressed-air service.

R. Install unions in copper compressed-air tubing adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.

S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Basic Division 22 Requirements."

T. Install escutcheons for piping penetrations of walls, ceilings and floors. Comply with requirements for escutcheons specified in Division 22 Section "Basic Division 22 Requirements."

3.4 VALVE INSTALLATION

A. Install shutoff valve at each outlet connection as well as to and from compressed-air equipment and specialties.

B. Install check valves to maintain correct direction of compressed-air flow from compressed-air equipment.
C. Install safety valves on compressed-air receivers where required by NFPA 99 and where recommended by specialty manufacturers.

D. Install pressure regulators on compressed-air piping where reduced pressure is required per the final user requirements.

E. Install automatic drain valves on equipment, specialties, and piping with drain connection. Run drain piping to floor drain so contents spill over or into it.

F. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter of each air compressor.

3.5 JOINT CONSTRUCTION

A. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

B. Threaded Joints: Apply appropriate tape to external pipe threads.

C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free dry nitrogen during brazing.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux to tube end. Join copper tube and fittings according to ASTM B 828.

E. Pressure-Sealed Joints: Join copper tube and press-type fittings with tools recommended by fitting manufacturer.

F. Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of memory-metal coupling joints.

3.6 COMPRESSED-AIR SERVICE COMPONENT INSTALLATION

A. Install compressed-air pressure control panel in walls. Attach to substrate.

B. Install compressed-air manifolds anchored to substrate or wall.

C. Install compressed-air cylinders and connect to manifold piping.

D. Install compressed-air manifolds with seismic restraints as indicated.

E. Install compressed-air-cylinder wall storage racks attached to substrate.

F. Attach Compressed distribution piping to the compressed air source equipment after the final source systems regulators.

3.7 LABORATORY COMPRESSED-AIR-PIPING ALARM SYSTEM INSTALLATION

A. Alarm panels for laboratory compressed-air piping systems may be combined in single panels with laboratory vacuum piping systems and specialty gas piping systems.

B. Install alarm panels for laboratory compressed-air piping system where indicated.

3.8 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.
3.9 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for nonmedical laboratory compressed-air piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.10 FIELD QUALITY CONTROL FOR COMPRESSED-AIR PIPING IN LABORATORY FACILITIES

A. Testing Agency: Engage qualified testing agency to perform field tests and inspections of compressed-air piping in nonmedical laboratory facilities and prepare test reports.

B. Perform tests and inspections of compressed-air piping in nonmedical laboratory facilities and prepare test reports.

C. Tests and Inspections:
   1. Piping Leak Tests for Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry nitrogen to pressure of 50 psig above system operating pressure, but not less than [150 psig] <insert pressure>. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
   2. Repair leaks and retest until no leaks exist.
   3. Inspect filters and pressure regulators for proper operation.

3.11 FIELD QUALITY CONTROL FOR LABORATORY COMPRESSED-AIR PIPING IN LABORATORY FACILITIES

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections of medical compressed-air piping in laboratory facilities and prepare test reports.

B. Perform tests and inspections of compressed-air piping systems in laboratory facilities and prepare test reports.

C. Tests and Inspections:
   1. Laboratory Compressed-Air Testing Coordination: Perform tests, inspections, verifications, and certification of medical compressed-air piping systems concurrently with tests, inspections, and certification of laboratory piping systems.
   2. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
      a. Inspections performed.
      b. Procedures, materials, and gases used.
      c. Test methods used.
      d. Results of tests.

D. Remove and replace components that do not pass tests and inspections and retest as specified above.

3.12 DEMONSTRATION

A. Engage factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain medical compressed-air alarm systems. Refer to Division 01 Section "Demonstration and Training."
3.13 ASSET TAGGING

A. Laboratory piping contractor will be responsible to obtain and the placing of and recording all asset tags on all relevant assets installed.

END OF SECTION 226115
SECTION 226213 – VACUUM PIPING FOR HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following:
1. Medical surgical vacuum piping and specialties, designated "medical vacuum" operating at 15 inches mercury (380 mm mercury or 50.7 kPa vacuum).
2. Waste anesthetic gas disposal piping and specialties, designated "WAGD evacuation" operating at 15 inches mercury (380 mm mercury or 50.7 kPa vacuum).
3. Dental vacuum piping and specialties, designated "dental vacuum" operating at 10 inches mercury (255 mm mercury or 33.8 kPa vacuum).
B. Related Sections include the following:
1. Division 12 Section "Healthcare Casework" for vacuum outlets in metal medical casework and pre-fabricated headwalls.

1.2 DEFINITIONS
A. D.I.S.S.: Diameter-index safety system.
B. MVE: Medical Vacuum Exhaust
C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
D. WAGD: Waste anesthetic gas disposal.
E. Medical vacuum piping systems include medical vacuum, WAGD evacuation, dental vacuum, and MVE piping systems.

1.3 SUBMITTALS
A. Product Data: For the following:
1. Vacuum pipe, fittings and components
2. Vacuum valves and valve boxes.
3. Medical vacuum service connections and vacuum-bottle brackets.
B. Sustainability/Sustainable Submittal:
1. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
C. Shop Drawings: Diagram power, signal, and control wiring.
D. Piping Material Certification: Signed by Installer certifying that medical vacuum piping materials comply with NFPA 99 requirements.
E. Qualification Data: For Installer and testing agency.
F. Brazing certificates.
G. Field quality-control test reports.
H. Operation and Maintenance Data: For vacuum piping specialties to include in emergency, operation, and maintenance manuals.
1.4 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Medical Vacuum Piping Systems for Healthcare Facilities: Qualify installers according to ASSE Standard #6010.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.
   1. Qualify testing personnel according to ASSE Standard #6020 for inspectors and ASSE Standard #6030 for verifiers.

C. Source Limitations: Obtain vacuum service connections of same type and from same manufacture as service connections provided for in Division 22 Section "Gas Piping for Laboratory and Healthcare Facilities."


E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with ASME B31.9, "Building Services Piping," for vacuum piping in laboratory facilities.


1.5 PROJECT CONDITIONS

A. Interruption of Existing Medical Vacuum Service(s): Do not interrupt medical vacuum service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Architect, Construction Manager, and Owner no fewer than seven (7) days in advance of proposed interruption of medical vacuum service(s).
   2. Do not proceed with interruption of medical vacuum service(s) without Architect's Construction Manager's, and Owner's written permission.

1.6 EXTRA MATERIALS

A. Provide 5% extra material for medical vacuum and WAGD outlets, and clean, capped and bagged 3-piece valves.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: Per the manufacturer listed.

B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.
2.2 PIPES, TUBES, AND FITTINGS

A. Copper Medical Gas Tube: ASTM B 819, Type L, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in blue.
   1. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
   2. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.
   3. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.

B. Stainless Steel Medical Gas Tube (Vacuum Systems Only): Stainless steel medical vacuum tube with welded joints and fittings in accordance with the following:
   1. ASTM A269/A269M, TP304L or 316L
   2. ASTM A312/A312M, TP304L or 316L
   3. A312 TP 304L/316L, Sch. 5S pipe, A403 WP304L/316L, Sch. 5S fittings.

C. Memory-Metal Couplings: Cryogenic compression fitting made of ASTM F 2063, nickel-titanium, shape-memory alloy, and that has been manufacturer cleaned, purged, and sealed for oxygen service according to CGA G-4.1.

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Smarttap Inc.

D. Axially Swaged Tube Fitting
   1. Contractor must be certified to ASSE 6010 for installation.
   2. Non brazing.
   3. No Nitrogen purge requirement.
   5. Fittings must meet CGA G4.1 standard for Oxygen clean.
   6. Couplings must have a "Thru-Bore" design.

      a. LOKRING.

2.3 MEDICAL VACUUM EXHAUST PIPE AND FITTINGS


   1. Rolled groove galvanized steel pipe and coupling system.

2.4 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness, full-face type.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.
2.5 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.
   1. Exception: Factory cleaning and bagging are not required for valves for WAGD service.

B. Copper-Alloy Ball Valves: MSS SP-110, 3-piece body, brass or bronze.
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      c. Amico Corporation.
      d. BeaconMedaes.
      e. Conbraco Industries, Inc.
      f. NIBCO INC.
      g. Squire-Cogswell/Aeros Instruments, Inc.
      h. Tri-Tech Medical.
   3. Pressure Rating: 300 psig (2070 kPa) minimum.
   5. Seats: PTFE or TFE.
   6. Handle: Lever type with locking device.
   7. Stem: Blowout proof with PTFE or TFE seal.

C. Bronze Check Valves: In-line pattern.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Amico Corporation.
      c. BeaconMedaes.
      d. Conbraco Industries, Inc.
      e. Squire-Cogswell/Aeros Instruments, Inc.
      f. Tri-Tech Medical.
   2. Pressure Rating: 300 psig minimum.

D. Zone Valves: MSS SP-110, 3-piece-body, brass or bronze ball valve with gage.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      c. Amico Corporation.
      d. BeaconMedaes.
      e. Squire-Cogswell/Aeros Instruments, Inc.
      f. Tri-Tech Medical.
2. Pressure Rating: 300 psig minimum.
4. Seats: PTFE or TFE.
5. Handle: Lever type with locking device.
6. Stem: Blowout proof with PTFE or TFE seal.
8. Vacuum Gage: Manufacturer installed on one copper-tube extension.

E. Zone Valve Boxes: Formed steel with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with vacuum gages and in sizes required to permit manual operation of valves.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Amico Corporation.
   d. BeaconMadaes.
   e. Squire-Cogswell/Aeros Instruments, Inc.
2. Interior Finish: Factory-applied white enamel.
3. Cover Plate: Aluminum or extruded-anodized aluminum with frangible or removable windows.
4. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

F. Safety Valves: Bronze-body, ASME-construction, pressure-relief type with settings to match system requirements.

2.6 MEDICAL VACUUM SERVICE CONNECTIONS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Amico Corporation.
5. Squire-Cogswell/Aeros Instruments, Inc.
6. Tri-Tech Medical.
B. Connection Devices: For specific medical vacuum service listed. Include roughing-in assemblies, finishing assemblies, and cover plates. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate. Furnish recessed-type units made for concealed piping unless otherwise indicated.
1. Roughing-in Assembly:
   a. Steel outlet box for recessed mounting and concealed piping.
   b. Brass-body inlet block.
   c. Seals that will prevent vacuum leakage.
   d. ASTM B 819, NPS 3/8 copper outlet tube brazed to valve with service marking and tube-end dust cap.
2. Finishing Assembly:
3. Quick-Coupler Service Connections: Suction inlets for medical vacuum and WAGD evacuation service outlets with non-interchangeable keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use.

4. D.I.S.S. Service Connections: Suction inlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.

5. Vacuum Bottle Brackets: One piece, with pattern and finish matching corresponding service cover plate.

6. Cover Plates: One piece, metal, and permanent, color-coded, identifying label matching corresponding service.

2.7 MEDICAL VACUUM PIPING ALARM SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Amico Corporation.
   5. Squire-Cogswell/Aeros Instruments, Inc.
   6. Tri-Tech Medical.

B. Panels for medical vacuum piping systems may be combined in single panels with medical compressed-air and medical gas piping systems.

C. Components: Designed for continuous service and to operate on power supplied from 120 V ac power source to alarm panels and with connections for low-voltage wiring to remote sensing devices. Include step-down transformers if required.

D. Vacuum Switches or Transducer Sensors: Continuous line monitoring with electrical connections for alarm system.
   1. Vacuum Operating Range: 0- to 30-in. Hg (0- to 101-kPa vacuum).

E. General Requirements for Medical Vacuum Alarm Panels: Factory wired with audible and color-coded visible signals to indicate specified functions.
   1. Mounting Recessed installation.
   2. Enclosures: Fabricated from minimum 0.047-inch- thick steel or minimum 0.05-inch-thick aluminum, with knockouts for electrical and piping connections.

F. Master Alarm Panels: With separate trouble alarm signals, vacuum gages, and indicators for medical vacuum piping systems.
   1. Include alarm signals when the following conditions exist:
a. Medical Vacuum: Vacuum drops below 12-in. Hg and backup vacuum pump is in operation.
b. WAGD Evacuation: Vacuum drops below 12-in. Hg.
c. Dental Vacuum: Vacuum drops below 6-in. Hg and backup vacuum producer is in operation.

G. Anesthetizing-Area Alarm Panels: Separate trouble alarm signals; vacuum gages; and indicators for medical vacuum piping systems.
   1. Include alarm signals when the following conditions exist:
      a. Medical Vacuum: Vacuum drops below 12-in. Hg
      b. WAGD Evacuation: Vacuum drops below 12-in. Hg.

H. Area Alarm Panels: Separate trouble alarm signals; vacuum gages; and indicators for medical vacuum piping systems.
   1. Include alarm signals when the following condition exists:
      a. Medical Vacuum: Vacuum drops below 12-in. Hg.

I. Dental Area Alarm Panels: Separate trouble alarm signals; vacuum gages; and indicators for medical vacuum piping systems.
   1. Include alarm signals when the following conditions exist:
      a. Dental Vacuum: Vacuum drops below 6-in. Hg and backup vacuum producer is in operation.
      b. HVE: 4-in. Hg and backup vacuum producer is in operation.

J. Medical Laboratory Area Alarm Panels: Separate trouble alarm signals; vacuum gages; and indicators for medical vacuum piping systems.
   1. Include alarm signals when the following condition exists:
      a. Medical Vacuum: Vacuum drops below 12-in. Hg.

2.8 COMPUTER INTERFACE CABINET
A. Description: Wall-mounting, welded-steel, control cabinet with gasketed door, mounting brackets, grounding device, and white-enamel finish for connection of medical vacuum piping system alarms to facility computer. Include factory-installed signal circuit boards, power transformer, circuit breaker, wiring terminal board, and internal wiring capable of interfacing [20] alarm signals.

2.9 FLEXIBLE PIPE CONNECTORS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Flex-Hose Co., Inc.
   2. Flexicraft Industries.
   3. Hyspan Precision Products, Inc.
   5. Metraflex, Inc.
   6. Proco Products, Inc.
   7. Unaflex.
   8. Universal Metal Hose; a Hyspan Co.
B. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   2. End Connections: Threaded copper pipe or plain-end copper tube.

2.10 NITROGEN
A. Description: Comply with USP 28 - NF 23 for oil-free dry nitrogen.

PART 3 - EXECUTION
3.1 PREPARATION
A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing are not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
   1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."
   2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb. (0.453 kg) of chemical to 3 gal. (11.3 L) of water.
      a. Scrub to ensure complete cleaning.
      b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING APPLICATIONS
A. Connect new copper tubing to existing tubing with memory-metal couplings.
B. Medical Vacuum Piping: Use the following piping materials for each size range:
   1. NPS 4 and Smaller: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
C. WAGD Evacuation Piping: Use the following piping materials for each size range:
   1. NPS 4 and Smaller: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
D. Dental Vacuum Piping: Use the following piping materials for each size range:
   1. NPS 4 and Smaller: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
E. Drain Piping: Use one of the following piping materials:
   1. Copper water tube, wrought-copper fittings, and soldered joints.

3.3 PIPING INSTALLATION
A. Drawing plans, schematics, and diagrams indicate general location and arrangement of vacuum piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
B. Comply with ASSE Standard #6010 for installation of vacuum piping.

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.

F. Install piping adjacent to equipment and specialties to allow service and maintenance.

G. Install vacuum and drain piping with 1 percent slope downward in direction of flow.

H. Install nipples, unions, and special fittings, and valves with pressure ratings same as or higher than piping pressure rating used in applications below unless otherwise indicated.

I. Install eccentric reducers, if available, where vacuum piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

J. Provide drain leg and drain trap at end of each main and branch and at low points.

K. Install thermometer and vacuum gage on inlet piping to each vacuum producer and on each receiver and separator. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping."

L. Install piping to permit valve servicing.

M. Install piping free of sags and bends.

N. Install medical vacuum piping to medical vacuum service connections specified in this Section and to equipment specified in other Sections requiring medical vacuum service.

O. Install medical vacuum service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

P. Install medical vacuum bottle bracket adjacent to each wall-mounted medical vacuum service connection suction inlet.

Q. Connect vacuum piping to vacuum producers and to equipment requiring vacuum service.

R. Install unions, in copper vacuum tubing adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.4 VALVE APPLICATIONS

A. Valves for Copper Vacuum Tubing: Use copper alloy ball and bronze check types.
3.5 VALVE INSTALLATION
A. Install shutoff valve at each connection to and from vacuum equipment and specialties.
B. Install check valves to maintain correct direction of vacuum flow to vacuum-producing equipment.
C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.
D. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.
E. Install safety valves on vacuum receivers, where required by NFPA 99, and where recommended by specialty manufacturers.
F. Install automatic drain valves on equipment, specialties, and piping with drain connection. Run drain piping to floor drain, so contents spill over or into it.
G. Install flexible pipe connectors in suction inlet piping to each vacuum producer.

3.6 JOINT CONSTRUCTION
A. Ream ends of pipes and tubes and remove burrs.
B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free dry nitrogen during brazing.
D. Soldered Joints: Apply ASTM B 813, water-flushable flux to tube end. Join copper tube and fittings according to ASTM B 828.
E. Flanged Joints:
   1. Copper Tubing: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.
F. Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of memory-metal coupling joints.

3.7 MEDICAL VACUUM PIPING ALARM SYSTEM INSTALLATION
A. Panels for medical vacuum piping systems may be combined in single panels with medical compressed-air piping systems and medical gas piping systems.
B. Install medical vacuum piping system alarm system components in locations required by and according to NFPA 99.
C. Install medical vacuum piping system area and master alarm panels where indicated.
D. Install computer interface cabinet with connection to medical vacuum piping alarm system and to facility computer.

3.8 LABELING AND IDENTIFICATION
A. Install identifying labels and devices for laboratory vacuum piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment."

VACUUM PIPING FOR HEALTHCARE FACILITIES 226213 - 10
3.9 FIELD QUALITY CONTROL FOR HEALTHCARE FACILITY MEDICAL VACUUM PIPING

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections of medical vacuum piping systems in healthcare facilities and prepare test reports.

B. Perform tests and inspections of medical vacuum piping systems in healthcare facilities and prepare test reports.

C. Tests and Inspections:
   1. Medical Vacuum Testing Coordination: Perform tests, inspections, verifications, and certification of medical vacuum piping systems concurrently with tests, inspections, and certification of oxygen, and medical gas piping systems.
   2. Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:
      a. Initial blow down.
      b. Initial pressure test.
      c. Cross-connection test.
      d. Piping purge test.
      e. Standing pressure test for vacuum systems.
      f. Repair leaks and retest until no leaks exist.

3. System Verification: Comply with requirements in NFPA 99, ASSE Standard #6020, and ASSE Standard #6030 for verification of medical vacuum piping systems and perform the following tests and inspections:
   a. Standing pressure test.
   b. Individual-pressurization or pressure-differential cross-connection test.
   c. Valve test.
   d. Master and area alarm tests.
   e. Piping purge test.
   f. Final tie-in test.
   g. Operational vacuum test.
   h. Verify correct labeling of equipment and components.

4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
   a. Inspections performed.
   b. Procedures, materials, and gases used.
   c. Test methods used.
   d. Results of tests.

D. Remove and replace components that do not pass tests and inspections and retest as specified above.

3.10 DEMONSTRATION

A. Engage factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain medical vacuum alarm systems. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 226213
SECTION 22621 – VACUUM PIPING FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Laboratory low-vacuum piping and specialties, designated "laboratory low vacuum" operating at 20 inches mercury.
   2. Laboratory high-vacuum piping and specialties, designated "laboratory high vacuum" operating at 24 inches mercury.

B. Related Sections include the following:
   1. Division 11 Section "Laboratory Fume Hoods" for vacuum outlets in laboratory fume hoods.
   2. Division 12 Section "Laboratory Casework" for vacuum outlets in casework.

1.2 SUBMITTALS

A. Product Data: For the following:
   1. Vacuum pipes and fittings.
   2. Vacuum valves and valve boxes.

B. Sustainability/Sustainable Submittal:
   1. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.

C. Shop Drawings: Diagram power, signal, and control wiring.

D. Qualification Data: For Installer and testing agency.

E. Brazing certificates.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For vacuum piping specialties to include in emergency, operation, and maintenance manuals.

1.3 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Extruded-Tee Outlet Procedure: Qualify operators according to training provided by T-DRILL Industries Inc., for making branch outlets.

B. Source Limitations: Obtain vacuum service connections of same type and from same manufacture as service connections provided for in Division 22 Section "Gas Piping for Laboratory Facilities."

C. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
E. Comply with ASME B31.9, "Building Services Piping," for vacuum piping in laboratory facilities.

1.4 PROJECT CONDITIONS
A. Interruption of Existing Laboratory Vacuum Service(s): Do not interrupt laboratory vacuum service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
1. Notify Architect, Construction Manager and Owner no fewer than 7 days in advance of proposed interruption of laboratory vacuum service(s).
2. Do not proceed with interruption of laboratory vacuum service(s) without Architect's, Construction Manager's, and Owner's written permission.

1.5 COORDINATION
A. Coordinate medical vacuum service connections with other service connections. Medical compressed-air service connections are specified in Division 22 Section "Compressed-Air Piping for Laboratory Facilities," and medical gas service connections are specified in Division 22 Section "Gas Piping for Laboratory Facilities."

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Basis of Design: Per the manufacturer listed.
B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

2.2 PIPES, TUBES, AND FITTINGS
A. Copper Medical Gas Tube: ASTM B 819, Type L, seamless, drawn temper.
   1. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
   2. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.
   3. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.

2.3 JOINING MATERIALS
A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
B. Threaded-Joint Tape: PTFE.
C. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness, full-face type.
D. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.
2.4 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.

B. Copper-Alloy Ball Valves: MSS SP-110, 3-piece body, brass or bronze.
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      c. Amico Corporation.
      d. BeaconMdeaes.
      e. Conbraco Industries, Inc.
      f. NIBCO INC.
      g. Squire-Cogswell/Aeros Instruments, Inc.
      h. Tri-Tech Medical.
   3. Pressure Rating: 300 psig minimum.
   5. Seats: PTFE or TFE.
   6. Handle: Lever type with locking device.
   7. Stem: Blowout proof with PTFE or TFE seal.

C. Bronze Check Valves: In-line pattern.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Amico Corporation.
      c. BeaconMdeaes.
      d. Conbraco Industries, Inc.
      e. Squire-Cogswell/Aeros Instruments, Inc.
      f. Tri-Tech Medical.
   2. Pressure Rating: 300 psig (2070 kPa) minimum.

D. Safety Valves: Bronze-body, ASME-construction, pressure-relief type with settings to match system requirements.

E. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig minimum working pressure, capable of automatic discharge of collected condensate. Include mounting bracket where wall mounting is indicated.
2.5 COMPUTER INTERFACE CABINET
A. Description: Wall-mounting, welded-steel, control cabinet with gasketed door, mounting brackets, grounding device, and white-enamel finish for connection of medical vacuum piping system alarms to facility computer. Include factory-installed signal circuit boards, power transformer, circuit breaker, wiring terminal board, and internal wiring capable of interfacing [20] <Insert number> alarm signals.

2.6 FLEXIBLE PIPE CONNECTORS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Flex-Hose Co., Inc.
2. Flexicraft Industries.
3. Hyspan Precision Products, Inc.
5. Metraflex, Inc.
6. Proco Products, Inc.
7. Unaflex.
8. Universal Metal Hose; a Hyspan Co.

B. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
2. End Connections: Threaded copper pipe or plain-end copper tube.

2.7 NITROGEN
A. Description: Comply with USP 28 - NF 23 for oil-free dry nitrogen.

PART 3 - EXECUTION

3.1 PREPARATION
A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing are not available or if precleaned fittings or tubing must be re-cleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."
2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb. of chemical to 3 gal. (11.3 L) of water.
   a. Scrub to ensure complete cleaning.
   b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING APPLICATIONS
A. Connect new copper tubing to existing tubing with memory-metal couplings.
3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of vacuum piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Comply with ASSE Standard #6010 for installation of vacuum piping.

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.

F. Install piping adjacent to equipment and specialties to allow service and maintenance.

G. Install vacuum and drain piping with 1 percent slope downward in direction of flow.

H. Install nipples, unions, and special fittings, and valves with pressure ratings same as or higher than piping pressure rating used in applications below unless otherwise indicated.

I. Install eccentric reducers, if available, where vacuum piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

J. Provide drain leg and drain trap at end of each main and branch and at low points.

K. Install thermometer and vacuum gage on inlet piping to each vacuum producer and on each receiver and separator. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping."

L. Install piping to permit valve servicing.

M. Install piping free of sags and bends.

N. Install medical vacuum piping to medical vacuum service connections specified in this Section and to equipment specified in other Sections requiring medical vacuum service.

O. Connect vacuum piping to vacuum producers and to equipment requiring vacuum service.

P. Install unions, in copper vacuum tubing adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.
Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Basic Division 22 Requirements."

R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Basic Division 22 Requirements."

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Basic Division 22 Requirements."

3.4 VALVE APPLICATIONS

A. Valves for Copper Vacuum Tubing: Use copper alloy ball and bronze check types.

3.5 VALVE INSTALLATION

A. Install shutoff valve at each connection to and from vacuum equipment and specialties.

B. Install check valves to maintain correct direction of vacuum flow to vacuum-producing equipment.

C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

D. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.

E. Install safety valves on vacuum receivers, where required by NFPA 99, and where recommended by specialty manufacturers.

F. Install automatic drain valves on equipment, specialties, and piping with drain connection. Run drain piping to floor drain, so contents spill over or into it.

G. Install flexible pipe connectors in suction inlet piping to each vacuum producer.

3.6 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Threaded Joints: Apply appropriate tape to external pipe threads.

E. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free dry nitrogen during brazing.

F. Soldered Joints: Apply ASTM B 813, water-flushable flux to tube end. Join copper tube and fittings according to ASTM B 828.

G. Flanged Joints:
   1. Copper Tubing: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.

H. Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of memory-metal coupling joints.
3.7 LABELING AND IDENTIFICATION
A. Install identifying labels and devices for laboratory vacuum piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment."

B. Prepare test reports.

3.8 FIELD QUALITY CONTROL FOR LABORATORY FACILITY NONMEDICAL VACUUM PIPING
A. Testing Agency: Engage a qualified testing agency to perform tests and inspections of medical vacuum piping systems in healthcare facilities and prepare test reports.

B. Perform tests and inspections of medical vacuum piping systems in healthcare facilities and prepare test reports.

C. Tests and Inspections:
   1. Laboratory Vacuum Testing Coordination: Perform tests, inspections, verifications, and certification of medical vacuum piping systems concurrently with tests, inspections, and certification of compressed-air piping systems.
   2. Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:
      a. Initial blow down.
      b. Initial pressure test.
      c. Cross-connection test.
      d. Piping purge test.
      e. Standing pressure test for vacuum systems.
      f. Repair leaks and retest until no leaks exist.
   3. System Verification: Comply with requirements in NFPA 99, ASSE Standard #6020, and ASSE Standard #6030 for verification of medical vacuum piping systems and perform the following tests and inspections:
      a. Standing pressure test.
      b. Individual-pressurization cross-connection test.
      c. Valve test.
      d. Master and area alarm tests.
      e. Piping purge test.
      f. Final tie-in test.
      g. Operational vacuum test.
      h. Verify correct labeling of equipment and components.
   4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
      a. Inspections performed.
      b. Procedures, materials, and gases used.
      c. Test methods used.
      d. Results of tests.

D. Remove and replace components that do not pass tests and inspections and retest as specified above.
3.9 DEMONSTRATION

A. Train Owner’s maintenance personnel to adjust, operate, and maintain medical vacuum alarm systems. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 226213
SECTION 226313 - GAS PIPING FOR HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
1. Carbon dioxide piping and specialties designated "medical carbon dioxide" operating at 50 to 55 psig
2. Helium piping, designated "medical helium" operating at 50 to 55 psig
3. Nitrogen piping and specialties designated "medical nitrogen" operating at 160 to 185 psig
4. Nitrous oxide piping and specialties designated "medical nitrous oxide" operating at .50 to 55 psig
5. Oxygen piping and specialties designated "medical oxygen" operating at 50 to 55 psig
6. Hyperbaric Oxygen Supply system, "medical Oxygen at approximately 90 psig.
7. Specialty gas piping and equipment designated "specialty operating at identified pressures.

B. Related Sections include the following:
1. Division 12 Section "Healthcare Casework" for gas outlets in metal medical casework.
2. Division 22 Section "Compressed-Air Piping for Healthcare Facilities".
3. Division 22 Section "Vacuum Piping for Healthcare Facilities".
4. Division 22 Section "Meters and Gages for Plumbing Piping".
5. Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

1.2 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.
B. D.I.S.S.: Diameter-index safety system.
C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
D. Medical gas piping systems include [medical carbon dioxide] [medical helium] [medical nitrogen] [medical nitrous oxide] [and] [medical oxygen] <Insert medical gas> nonflammable gas for healthcare facility patient care or for healthcare laboratory applications.
E. Specialty Gas: Gas, other than medical gas, for nonmedical laboratory facility applications.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store large medical gas accessories on factory-installed shipping skids, tubing with sealing plugs in ends or with end protection, and small accessories in factory-fabricated fiberboard containers.
1. Store precleaned and sealed medical gas tube, fittings, valves, and accessories with sealing plugs and sealing packaging intact.
2. Label medical gas tube, fittings, valves, and accessories that have not been precleaned, and that have been precleaned but have seal or packaging that is not precleaned, and that have been precleaned and have seal or packing that is not intact, with temporary labels indicating that cleaning is required before installation.
1.4 SUBMITTALS

A. Product Data: For the following:

1. Tubes and fittings.
2. Valves and valve boxes.
3. Medical gas service connections.
4. Patient service consoles.
5. Medical nitrogen pressure control panels.
7. Gas manifolds.
8. Medical gas alarm system components.
9. Gas cylinder storage racks.
10. Special purpose valves.
11. Medical gas accessories.
12. Combination drawings for medical gas systems.
13. Inspection and test reports specified in "Field Quality Control" in this Section.
14. Certificates of inspections and tests from independent testing agency specified in "Field Quality Control" in this Section.
15. Maintenance data for inclusion in Operating and Maintenance Manuals.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Piping Material Certification: Signed by Installer certifying that medical gas piping materials comply with NFPA 99 requirements.

D. Qualification Data: For Installer and testing agency.

E. Brazing certificates.

F. Certificates of Shop Inspection and Data Report for Bulk Gas Storage Tanks: As required by ASME Boiler and Pressure Vessel Code.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For specialty and medical gas piping and equipment to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Medical Gas Piping Systems for Healthcare Facilities: Qualify installers according to ASSE Standard #6010 for installers.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the medical gas piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel according to ASSE Standard #6020 for inspectors and ASSE Standard #6030 for verifiers.

C. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications"; or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."
D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. ASME Compliance: Fabricate and label bulk medical gas storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

F. NFPA Compliance:


H. UL Compliance:
   2. Comply with UL 544, "Medical and Dental Equipment," for medical gas specialties.

I. Isolated Power System: Where equipment is used with isolated power system, provide equipment listed for that purpose.

J. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code", Article 100.

K. Listing and Labeling: Provide equipment that is UL listed and labeled.

L. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

M. Product Options: Medical gas system equipment and components are based on the specific types, manufacturers, and models indicated. Equipment and components having equal performance characteristics by other manufacturers may be considered, provided that deviations in dimensions, operation and other characteristics to not change the design concept or intended performance as judged by the Architect. The burden of proof of equality of products is on the proposer. Refer to Division 01 Section "Product Substitutions."

1.6 PROJECT CONDITIONS

A. Interruption of Existing Specialty and Medical Gas Service(s): Do not interrupt gas services serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Architect, Construction Manager and Owner no fewer than seven (7) days in advance of proposed interruption of gas service(s).
   2. Do not proceed with interruption of gas service(s) without Architect's, Construction Manager's and Owner's written permission.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate medical gas service connections with other service connections. Compressed-air service connections are specified in Division 22 Sections "Compressed-Air Piping for Laboratory and Healthcare Facilities" and "Vacuum Piping for Healthcare Facilities."
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: Per the manufacturer listed.

B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

2.2 PIPES, TUBES, AND FITTINGS

A. Copper Medical Gas Tube: ASTM B 819, Type L, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and blue for Type L tube.

1. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.

2. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.

3. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.

4. Memory-Metal Couplings: Cryogenic compression fitting made of ASTM F 2063, nickel-titanium, shape-memory-alloy, and that has been manufacturer cleaned, purged, and sealed for oxygen service according to CGA G-4.1.

a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1) Smarttap Inc.

   b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2.3 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.

B. Threaded-Joint Tape: PTFE.

2.4 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.

B. Ball Valves: MSS SP-110, 3-piece, union type body, brass or bronze.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   c. Amico Corporation.
   d. BeaconMedaes.
   e. Conbraco Industries, Inc.
   f. NIBCO INC.
   g. Squire-Cogswell/Aeros Instruments, Inc.
   h. Tri-Tech Medical.
2. Pressure Rating: 300 psig minimum.
4. Seats: PTFE or TFE.
5. Handle: Lever type with locking device.
6. Stem: Blowout proof with PTFE or TFE seal.
8. Provide factory-cleaned, factory-sealed (for oxygen use), and factory-installed, Type L copper tube extensions with pressure gage installed downstream from valve in pressure systems and upstream from valve in vacuum systems.

C. Check Valves: In-line pattern, bronze.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Amico Corporation.
   c. BeaconMedaes.
   d. Conbraco Industries, Inc.
   e. Squire-Cogswell/Aeros Instruments, Inc.
   f. Tri-Tech Medical.
2. Pressure Rating: 300 psig (2070 kPa) minimum.
4. Check Valves 3 Inches and Smaller: Bronze body, straight through pattern, spring loaded ball check valve.
5. Check valves 4 Inches and Larger: Class 250, iron body, bronze trim, swing check valve with flanged ends.

D. Zone Valves: MSS SP-110, 3-piece-body, brass or bronze ball valve with gage and capped port.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Amico Corporation.
   d. BeaconMedaes.
   e. Squire-Cogswell/Aeros Instruments, Inc.
   f. Tri-Tech Medical.
2. Pressure Rating: 300 psig minimum.
4. Seats: PTFE or TFE.
5. Handle: Lever type with locking device.
6. Stem: Blowout proof with PTFE or TFE seal.
8. Pressure Gage: Manufacturer-installed on one copper-tube extension.

E. Zone Valve Boxes: Formed steel with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2.5 MEDICAL GAS SERVICE CONNECTIONS

A. Manufacturers: Subject to compliance with connection types, requirements and Medical Gas Outlet Schedule, provide products by one of the following:

3. Amico Corporation.
5. Tri-Tech Medical.

GAS PIPING FOR HEALTHCARE FACILITIES

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B. General Requirements for Medical Gas Service Connections: For specific medical gas pressure and suction service listed. Include roughing-in assemblies, finishing assemblies, and cover plates. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate. Furnish recessed-type units made for concealed piping unless otherwise indicated.

1. Roughing-in Assembly:
   a. Steel outlet box for recessed mounting and concealed piping.
   b. Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed. Suction inlets to be without secondary valve.
   c. Double seals that will prevent gas leakage.
   d. ASTM B 819, NPS 3/8 (DN 10) copper outlet tube brazed to valve with service marking and tube-end dust cap.

2. Finishing Assembly:
   a. Brass housing with primary check valve.
   b. Double seals that will prevent gas leakage.
   c. Cover plate with gas-service label.

3. Quick-Coupler Service Connections: Pressure outlets for carbon dioxide, nitrous oxide, oxygen and Nitrogen service connections with non-interchangeable keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use.

4. D.I.S.S. Service Connections: Pressure outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.
   d. Medical Nitrous Oxide Service Connections: D.I.S.S. No. 1040.

5. Cover Plates: One piece anodized aluminum and permanent, color-coded, identifying label matching corresponding service.

2.6 PATIENT SERVICE CONSOLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Amico Corporation.
   2. BeaconMedaes.
   3. Tri-Tech Medical.

B. General Requirements for Patient Service Consoles: Recessed- or semi-recessed-mounting wall units with medical gas service connections as specified in "Medical Gas Service Connections" Article Include labels indicating services, and the following:
   1. Recessed- or semi-recessed-mounting steel console box or mounting bracket.
   2. Concealed supplies.
   3. Cover Plate: One piece, anodized aluminum and permanent identifying label with service connections for the following:
2.7 MEDICAL NITROGEN PRESSURE CONTROL PANELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Amico Corporation.
   4. Squire-Cogswell/Aeros Instruments, Inc.
   5. Tri-Tech Medical.

B. Description: Steel box and support brackets for recessed roughing-in with stainless-steel or anodized-aluminum cover plate with printed operating instructions. Include manifold assembly consisting of inlet supply valve, inlet supply pressure gage, line-pressure control regulator, outlet supply pressure gage, D.I.S.S. service connection, and piping outlet for remote service connection.
   2. Line-Pressure Control Regulator: Self-relieving diaphragm type with precision manual adjustment.
   3. Pressure Gages: 0- to 300-psig range.
   5. Before final assembly, provide temporary dust shield and U-tube for testing.
   6. Label cover plate "Nitrogen Pressure Control."

2.8 CEILING HOSE ASSEMBLIES

A. Ceiling Hose Assemblies, General: Ceiling-mounting units with medical gas service connections as specified in "Medical Gas Service Connections" Include labels indicating services, and the following:
   1. Ceiling-Mounting Plate: Manufacturer’s standard plate or roughing-in assembly.
   2. Exposed Surfaces: Minimum 0.0375-inch- thick stainless steel with NAAMM AMP 503, No. 4 directional polish.
   3. Servicing: Include access panels or means of removing shroud.
   4. Blank cover plates for cutouts not having service connections.
   5. ASTM B 819, NPS 3/8 copper-tube extensions for connection to medical gas systems.
   6. Service Connections: Type and number indicated.
   7. Dust Covers: For medical gas service connection.

B. Fixed Hose Service Assemblies: Individual, concealed hose connection with stainless-steel face plates, steel mounting boxes, factory- or field-fabricated mounting brackets, and color-coded service hoses with retractor device and service connections matching hoses. Include [72 inches] <insert dimension> of conductive, CR, 1/4- or 5/16-inch- ID, medical gas hoses rated for 200-psig minimum working pressure, and the following service hose connections:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      c. Amico Corporation.
      d. BeaconMedaes.
e. Squire-Cogswell/Aeros Instruments, Inc.

f. Tri-Tech Medical.


3. Medical Carbon Dioxide Hose: [Quick-coupler] [D.I.S.S. No. 1080] pressure outlet.


5. Medical Nitrous Oxide Hose: [Quick-coupler] [D.I.S.S. No. 1040] pressure outlet.


7. Alternate medical gas Hose:


2.9 GAS MANIFOLDS

A. Medical Gas Manifolds: Comply with NFPA 99, Ch. 5, for high-pressure medical gas cylinders.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   c. Amico Corporation.
   d. BeaconMedaes.
   e. Squire-Cogswell/Aeros Instruments, Inc.
   f. Tri-Tech Medical.

2. Central Control Panel Unit: Weatherproof cabinet, supply and delivery pressure gages, electrical alarm system connections and transformer, indicator lights or devices, manifold connection, pressure changeover switch, line-pressure regulator, shutoff valves, and safety valve.

3. Manifold and Headers: Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks. Units include design for 2000-psig minimum inlet pressure, except nitrous oxide manifolds may be designed for 800 psig and carbon dioxide manifolds may be designed for 1500 psig. Include cylinder bank headers with inlet (pigtail) connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.

4. Operation: All manifolds shall have automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder bank header.

5. Medical Gas Manifolds:

6. Refer to the drawing schedule for the manifold type, model number and quantity of connections.

7. Medical Gas Cylinders: Will be furnished by Owner Label manifold control unit with permanent label identifying medical gas type and system operating pressure.

8. Mounting: Floor with support legs for manifold control cabinet.

2.10 MEDICAL GAS PIPING ALARM SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

3. Amico Corporation.
5. Squire-Cogswell/Aeros Instruments, Inc.
6. Tri-Tech Medical.

B. Panels for medical gas piping systems may be combined in single panels with medical compressed-air and medical vacuum piping systems.

C. Components: Designed for continuous service and to operate on power supplied from 120V ac power source to alarm panels and with connections for low-voltage wiring to remote sensing devices. Include step-down transformers if required.

D. Pressure Switches or Pressure Transducer Sensors: Continuous line monitoring with electrical connections for alarm system.
   1. Low-Pressure Operating Range: 0- to 100-psig.
   2. High-Pressure Operating Range: Up to 250-psig.

E. General Requirements for Medical Gas Alarm Panels: Factory wired with audible and color-coded visible signals to indicate specified functions.
   1. Mounting: Recessed installation.
   2. Enclosures: Fabricated from minimum 0.047-inch-thick steel or minimum 0.05-inch-thick aluminum, with knockouts for electrical and piping connections.


G. Provide dew point monitors for continuous line monitoring having panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, factory- or digital display, pipeline sensing element, electrical connections for alarm system, factory- or field-installed valved bypass, and a visual and cancelable audio signal for dryer site and master alarm panels. Alarm shall operate when pressure dew point rises above 39 deg F at 55 psig.
   1. Operation: Chilled mirror method.
   2. Operation: Hygrometer moisture analyzer with sensor probe.

H. Provide carbon monoxide monitors having panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, and factory- or field-installed valved bypass. Alarm shall operate when carbon monoxide level rises above 10 parts per million.

I. Master Alarm Panels: With separate trouble alarm signals, pressure gages, and indicators for medical gas piping systems.
   1. Include alarm signals when the following conditions exist:
      a. Medical Gas Systems: Pressure downstream from main shutoff valve drops below 40 psig or rises above 60 psig and changeover is made to alternate bank.

J. Area Alarm Panels: Separate trouble alarm signals; pressure and vacuum gages; and indicators for medical gas piping systems.
   1. Include alarm signals when the following conditions exist:
      a. Medical Gas: Pressure drops below 40 psig or rises above 60 psig

K. Dental Area Alarm Panels: Separate trouble alarm signals; pressure and vacuum gages; and indicators for Dental gas piping systems.
   1. Include alarm signals when the following conditions exist:
a. Medical Nitrogen: Pressure drops below 145 psig or rises above 200 psig and changeover is made to alternate bank.
b. Medical Nitrous Oxide: Pressure drops below 40 psig or rises above 60 psig and changeover is made to alternate bank.
c. Medical Oxygen: Pressure downstream from main shutoff valve drops below 40 psig or rises above 60 psig and changeover is made to alternate bank.

PART 3 - EXECUTION

3.1 PREPARATION

A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing are not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction.

3.2 EARTHWORK

A. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling and for underground warning tapes.

3.3 PIPING APPLICATIONS

A. Medical Gas Piping: Use Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
B. Medical Nitrogen Piping: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
C. Medical Nitrogen Piping NPS 2-1/2 and Smaller: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.

3.4 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of gas piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
B. Comply with ASSE Standard #6010 for installation of medical gas piping.
C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
F. Install piping adjacent to equipment and specialties to allow service and maintenance.
G. Install nipples, unions, and special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications below unless otherwise indicated.
H. Install piping to permit valve servicing.
I. Install piping downward slope in direction of air flow.
J. Install eccentric reducers where pipe is reduced in size in direction of flow, with bottoms of both pipes and reducer flush.

K. Connect branch piping to mains from top of main. Provide drain leg and drain trap at end of each main, each branch and each low point in piping system.

L. Install piping free of sags and bends.

M. Install fittings for changes in direction and branch connections.

N. Install medical gas piping to medical gas service connections specified in this Section, to medical gas service connections in equipment specified in this Section, and to equipment specified in other Sections requiring medical gas service.

O. Install exterior, buried medical gas piping in protective conduit fabricated with concrete pipe sleeve and fittings. Solvent cement joints to conform to ASTM D 2855. Do not extend conduit through foundation wall.

P. Extend tubing to connect to bulk storage tanks and exterior manifolds, of sizes and in locations indicated for service entrances to building.

Q. Install sleeve and mechanical sleeve seal at penetrations through foundation wall for watertight installation.

R. Install medical gas service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

S. Connect gas piping to gas sources and to gas outlets and equipment requiring gas service.

T. Install unions, in copper tubing adjacent to each valve and at final connection to each piece of equipment and specialty.

U. Install 1-inch-thick extruded polystyrene insulation over buried medical gas tubing not under building. Width of insulation shall extend minimum of 12 inches beyond each side of tubing and casing.

V. Seal pipe penetrations of fire barriers using fire barrier penetration sealers specified in Division 22 Section "Common Work Results for Plumbing."

W. Install thermometers and pressure gages in accordance with Division 22 Section "Meters and Gages for Plumbing Piping."

X. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

Y. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Basic Division 22 Requirements."

Z. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.5 VALVE INSTALLATION

A. Install shutoff valve at each connection to healthcare equipment and specialties. Provide floor control valves at riser points for floor distribution piping.

B. Install check valves to maintain correct direction of gas flow from laboratory and healthcare gas supplies.
C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

D. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.

E. Install pressure regulators on gas piping where reduced pressure is required.

F. Install emergency oxygen connection with pressure relief valve and full-size discharge piping to outside, with check valve downstream from pressure relief valve and with ball valve and check valve in supply main from bulk oxygen storage tank.

G. Use ball valves specified in this Section for main shutoff and zone valve duties.

3.6 JOINT CONSTRUCTION

A. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

B. Threaded Joints: Apply appropriate tape to external pipe threads.

C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free, dry nitrogen during brazing.

D. Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of memory-metal coupling joints.

3.7 GAS SERVICE COMPONENT INSTALLATION

A. Assemble patient service console with service connections. Install with supplies concealed, in walls. Attach console box or mounting bracket to substrate.

B. Install nitrogen pressure-control panels in walls. Attach to substrate.

C. Assemble ceiling assemblies and install anchored to substrate. Provide structural steel, hanger rods, anchors, and fasteners in addition to components furnished with specialties necessary to fabricate supports.

D. Install gas manifolds on concrete base anchored to substrate and seismic controls as indicated.

E. Install gas cylinders and connect to manifold piping.

3.8 MEDICAL GAS PIPING ALARM SYSTEM INSTALLATION

A. Install medical gas alarm system components in locations required by and according to NFPA 99.

B. Install medical gas area and master alarm panels where indicated.

3.9 CONNECTIONS

A. Install tubing and piping adjacent to equipment to allow servicing and maintenance.

B. Connect medical gas tubing to bulk storage tanks with unions. Install with ball valves and strainers where required.

C. Connect medical gas tubing to equipment, gas manifolds, and accessories with unions. Install with ball valves and strainers.
1. Install flexible pipe (tubing) connectors on air tubing connections to medical air compressors, vacuum tubing connections to medical vacuum pumps, and where indicated.
2. Install thermometers on medical air compressor discharge tubing, medical air receiver tanks, medical vacuum receiver tanks, and where indicated.
3. Install pressure gages on medical air compressor discharge tubing, air receiver tanks, vacuum receiver tanks, and where indicated.
4. Install pressure regulators downstream from medical air system compressors, dryers, purification units, and filter assemblies.

D. Install medical gas tubing to medical gas alarm system components.

3.10 HANGER AND SUPPORT INSTALLATION
A. Comply with requirements in Division 220529 “Hangers and Supports.”

3.11 LABELING AND IDENTIFICATION
A. Install identifying labels and devices for specialty gas piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.12 FIELD QUALITY CONTROL FOR HEALTHCARE FACILITY MEDICAL GAS
A. Testing Agency: Engage a qualified testing agency to perform tests and inspections of medical gas piping systems in healthcare facilities and prepare test reports.
B. Independent Testing Agency Services: Provide services of an independent testing agency meeting requirements of Division 01 Section "Quality Control Services" to inspect, test, and certify medical gas systems as specified below. Testing agency work does not include Installer quality control procedures or tests.
   1. Inspect, test, and certify complete medical gas systems in accordance with the requirements of NFPA 99, Standard for Health Care Facilities. Inspect, test, and certify each medical gas system, including each tubing system, outlets and inlets, accessories, alarm panels and devices, safety devices, medical gas sources, and equipment.
C. System Clearing: Purge medical gas system piping using oil-free dry air or nitrogen after installation of piping but before installation of service outlet valves, alarms and gages.
D. Perform field tests and inspections of specialty gas piping for non-healthcare laboratory facilities and prepare test reports.
E. Tests and Inspections:
   1. Piping Leak Tests for Specialty Gas Piping: Test new and modified parts of existing piping. Cap and fill specialty gas piping with oil-free, dry nitrogen to pressure of 50 psig above system operating pressure, but not less than [150 psig] <Insert pressure>. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
   2. Repair leaks and retest until no leaks exist.
   3. Inspect specialty gas regulators for proper operation.
F. Perform tests and inspections of medical gas piping systems in healthcare facilities and prepare test reports.
G. Tests and Inspections:

1. Medical Gas Piping Testing Coordination: Perform tests, inspections, verifications, and certification of medical gas piping systems concurrently with tests, inspections, and certification of systems.

2. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:
   a. Initial blow down.
   b. Initial pressure test: Subject each section of each system, except high-pressure air and nitrogen, to test pressure of from 150 psig to 200 psig and high-pressure air and nitrogen systems to test pressure of 250 psig with oil-free dry air or nitrogen before attachment of system components, after installation of station outlets with test caps (when supplied) in place, and before concealing piping system. Maintain test until joints are examined for leaks by means of soapy water.
   c. Cross-connection test.
   d. Piping purge test.
   e. Standing pressure test for positive pressure medical gas piping: Install assembled system components after testing individual systems as specified above. Subject systems to 24-hour standing-pressure test at 20 percent above normal line pressure but not less than 66 psig.
   f. Standing pressure test for vacuum systems. Subject vacuum and evacuation systems to 12 to 18 inches of mercury minimum vacuum.
   g. Repair leaks and retest until no leaks exist.

3. System Verification: Comply with requirements in NFPA 99, ASSE Standard #6020, and ASSE Standard #6030 for verification of medical gas piping systems and perform the following tests and inspections:
   a. Standing pressure test.
   b. Pressure-differential cross-connection test.
   c. Valve test.
   d. Master and area alarm tests.
   e. Piping purge test.
   f. Piping particulate test.
   g. Piping purity test.
   h. Final tie-in test.
   i. Operational pressure test.
   j. Medical gas concentration test.
   k. Medical air purity test.
   l. Verify correct labeling of equipment and components.
   m. Verify the following source equipment:
      1) Medical gas supply sources.

4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
   a. Inspections performed.
   b. Procedures, materials, and gases used.
   c. Test methods used.
   d. Results of tests.

H. Remove and replace components that do not pass tests and inspections and retest as specified above.
A. Engage factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain source equipment, bulk gas storage tanks and medical gas alarm system. Refer to Division 01 Section “Demonstration and Training.”
SECTION 226600 - CHEMICAL-WASTE SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   2. Double-containment piping.
   3. Field-fabrication containment piping.
   4. Piping specialties.
   5. Neutralization tanks.
   6. Neutralization systems.
   7. Manholes.
   8. Leak-detection systems.
   9. Prefabricated pH Neutralization Systems

1.2 DEFINITIONS

A. CPVC: Chlorinated polyvinyl chloride plastic.
B. CR: Chlorosulfonated polyethylene synthetic rubber.
C. EPDM: Ethylene-propylene-diene terpolymer rubber.
D. ETFE: Ethylene tetrafluoroethylene.
E. FEP: Perfluoro ethylene-propylene plastic.
F. FPM: Vinylidene fluoride-hexafluoro propylene copolymer rubber.
G. PE: Polyethylene plastic.
H. PFA: Perfluoro alkoxyalkane plastic.
I. PP: Polypropylene plastic.
J. PTFE: Polytetrafluoroethylene plastic.
K. Double-Containment Piping System: Factory-fabricated pipe and fittings consisting of carrier (inner) pipe and containment (outer) pipe with spacers between inner and outer pipes.
L. Field-Fabrication Containment Piping: Split pipe and fittings manufactured for installation over existing pipe and fittings and joined by gaskets and clamps or adhesive.

1.3 PERFORMANCE REQUIREMENTS

A. Single-Wall Piping Pressure Rating: 10 feet head of water.
B. Double-Containment Piping Pressure Rating:
   1. Carrier Piping: 5-psig air test pressure.
   2. Containment Piping: 5-psig air test pressure.
C. Force-Main Piping:
   1. Single-Wall Piping Pressure Rating: At least equal to 150% of expected system operating pressure but not less than 50 psig.
D. Field-Fabrication Containment-Piping Pressure Rating: air test pressure.

E. Delegated Design: Design seismic restraints for aboveground piping, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Division 22 Section "Basic Division 22 Requirements."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For neutralization system and leak-detection system.
   1. Layout Drawings: Include plans, elevations, sections, details, and attachments to other work.
      a. Detail neutralization-system assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
      b. Detail leak-detection-system assemblies and indicate required clearances, method of field assembly, components, and location and size of each field connection.

2. Wiring Diagrams: For power, signal, and control wiring.

3. Sustainability/Sustainable Applicability:
   a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.

C. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from sewerage system piping. Indicate interface and spatial relationship between piping and proximate structures.
   1. Drawings for Equipment, above slab and Underground Piping: Indicate sloped piping. Show equipment material types, sizes, and elevations of system and other utilities crossing system piping.

D. Delegated-Design Submittal: For seismic restraints of aboveground piping, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.6 INFORMATIONAL SUBMITTALS

A. Field Quality Control Test Reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For chemical-waste specialties and neutralization systems, and leak-detection systems to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 70, "National Electrical Code."
C. Source Limitations: Obtain pipe, fittings, and joining materials for each piping system through one source from a single manufacturer.
   1. Exception: Piping from different manufacturers may be used in same system if indicated and suitable transition fittings matching both piping materials are used.

D. Piping materials shall bear label, stamp, or other markings of specified testing laboratory.

1.9 DELIVERY, STORAGE, AND HANDLING
A. Deliver and store piping and specialties with sealing plugs in ends or with end protection.
B. Do not store plastic pipe or fittings in direct sunlight.
C. Protect pipe, fittings, and seals from dirt and damage.

1.10 PROJECT CONDITIONS
A. Interruption of Existing Chemical-Waste Service: Do not interrupt chemical-waste service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary chemical-waste service according to requirements indicated:
   1. Notify Architect, Construction Manager and Owner no fewer than seven (7) days in advance of proposed interruption of chemical-waste service.
   2. Do not proceed with interruption of chemical-waste service without Architect's, Construction Manager's and Owner's written permission.

1.11 COORDINATION
A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Basis of Design: Per the manufacturer listed.
B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.

2.2 SINGLE-WALL PIPE AND FITTINGS
A. PE Drainage Pipe and Fittings: Made of ASTM D 4976, PE resin.
   1. Manufacturers:
      a. ISCO Industries, LLC.
      b. Performance Pipe; a division of Chevron Phillips Chemical Company LLC.
B. Flame Retardant Polypropylene, FRPP Drainage Pipe and Fittings: ASTM F 1412, pipe extruded and drainage-pattern fittings molded, with Schedule 40 dimensions, from PP resin with fire-retardant additive complying with ASTM D 4101; with fusion- and mechanical-joint ends.

1. Exception: Pipe and fittings made from PP resin without fire-retardant additive may be used for underground installation.

2. Manufacturers:
   a. IPEX Inc.
   b. Orion Fittings, Inc.; a division of Watts Water Technologies, Inc.
   c. Sloane, George Fischer, Inc.
   d. Town & Country Plastics, Inc.
   e. Watts Industries (Canada), Inc.
   f. Zurn Plumbing Products Group; Chemical Drainage Systems.

C. Flame Retardant Polypropylene FRPP Pressure Pipe and Fittings: Pipe extruded and fittings molded from PP resin complying with ASTM D 4101; with Schedule 80 dimensions and socket, butt-fusion, or threaded fittings.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Asahi/America.
   b. Fischer, George, Inc.
   c. Flo Safe, Inc.
   d. NIBCO INC.; Chemtrol Div.
   e. Town & Country Plastics, Inc.

2.3 DOUBLE-CONTAINMENT PIPE AND FITTINGS

A. Manufacturers:

1. Ameron International; Fiberglass Pipe Group.
2. Asahi/America.
3. Eslon Thermoplastics; Guardian Div.
4. Fischer, George, Inc.
5. Flo Safe, Inc.
7. IPEX Inc.
8. IPEX Inc.; Guardian Div.
9. NIBCO INC.
10. Orion Fittings, Inc.; a division of Watts Water Technologies, Inc.
11. Performance Pipe; a division of Chevron Phillips Chemical Company LLC.
12. Rovanco Piping Systems, Inc.
14. Thermacor Process, L.P.
B. Description: Factory-fabricated, double-wall pipe and fittings. Sizes indicate carrier-pipe size; with carrier (inner) pipe and fittings; annular-space, carrier-pipe supports; containment (outer) pipe and fittings; and joining materials and fasteners. Include manufacturer's standard piping materials according to the following:

1. PE, Double-Containment Drainage Pipe and Fittings: Made of ASTM D 4976, PE resin.

2. PE, Double-Containment Pressure Pipe and Fittings: Made of ASTM D 4976, PE resin.
   a. Carrier Pipe and Fittings: ASTM D 2447, Schedule 80; with combination of resin, pipe size, and wall thickness that can provide \(160\)-psig <system-insert:dimension> minimum, sustained water test pressure rating.
   b. Containment Pipe and Fittings: ASTM D 2447, Schedule [40] [80].


   a. Carrier Pipe and Fittings: Schedule 80, made to ASTM D 2447 dimensions; with combination of resin, pipe size, and wall thickness that can provide \(160\)-psig <system-insert:dimension> minimum, sustained water test pressure rating.
   b. Containment Pipe and Fittings: Schedule [40] [80], made to ASTM D 2447 dimensions.

5. PP/PVC, Double-Containment Pressure Pipe and Fittings:
   a. PP Carrier Pipe and Fittings: Schedule 80, made to ASTM D 2447 dimensions; made of ASTM D 4101, PP resin; with combination of resin, pipe size, and wall thickness that can provide 160-psig minimum, sustained water test pressure rating.
   b. PVC Containment Pipe and Fittings: ASTM D 1785, Schedule 40 PVC pipe and ASTM D 2466, Schedule 40 PVC fittings.

2.4 FIELD-FABRICATION CONTAINMENT PIPING

A. Manufacturers:
   1. Flo Safe, Inc.
   2. Sloane, George Fischer, Inc.

B. With carrier-pipe centralizers. Include manufacturer's fastening devices and materials.
   1. Material: FRPP pipe and fittings.
   2. Fastening System: FPM gaskets, clamps, and pins.
   3. Material: Clear PVC pipe and fittings with adhesive channels, for use with drainage-pattern carrier piping.
Froedtert Health
Milwaukee, Wisconsin
Master Specifications Version 7

2.5 FIELD-FABRICATION CONTAINMENT PIPING FOR EXISTING CARRIER PIPING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Sloane, George Fischer, Inc.

C. Description: Containment split pipe and split fittings with carrier pipe centralizers; and with manufacturer's fastening devices and materials.

1. Material: Clear PVC split pipe with adhesive channels and split fittings for use with drainage-pattern carrier pipe fittings.

2. Fastening System: Adhesive for pipe and fittings and clips for fittings.

2.6 JOINING MATERIALS

A. Couplings: Assemblies with combination of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.

B. Adapters and Transition Fittings: Assemblies with combination of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.

C. Flanges: Assemblies of companion flanges and gaskets complying with ASME B16.21 and compatible with system liquid, and bolts and nuts.

D. Solvent Cement for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

1. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 PIPING SPECIALTIES

A. Corrosion-Resistant Traps:

1. Type: P-trap or drum trap.
2. Size: NPS 1-1/2 or NPS 2, as required to match connected piping.
3. High-Silicon Iron: ASTM A 861, with horizontal outlet and hub-and-plain or plain ends to match connecting piping.
4. PP: ASTM D 4101, with mechanical-joint pipe connections.
5. PVDF: ASTM D 3222, with mechanical-joint pipe connections.

B. High-Silicon-Iron Floor Drains:

1. Manufacturers:
   a. Flowserve Corporation; Foundry Operations.
3. Body: With integral flashing flange and weep holes; and with [flashing ring and stainless-steel strip] [sediment basin] [and] [funnel attachment].
4. Top: 8-3/4-inch diameter with grate.
5. Size: NPS 2, NPS 3, NPS 4, or NPS 6 outlet as indicated.
C. Stainless-Steel Floor Drains:
   1. Manufacturers:
      a. Josam Company; Blucher-Josam Div.
      b. <Insert manufacturer's name>.
   2. Standard: ASME A112.3.1, ASTM A 666, Type 316L.
   3. Body: With 12.4-by-12.4-inch top with grate.
   4. Outlet: Bottom, of size indicated.

D. PP Floor Drains:
   1. Manufacturers:
      a. IPEX, Inc.
      b. Orion Fittings, Inc.; a division of Watts Water Technologies, Inc.
      c. Schier Products Company.
      d. Sloane, George Fischer, Inc.
      e. Town & Country Plastics, Inc.
      f. Watts Industries (Canada), Inc.
   2. Body: With 7- to 9-inch top diameter, with flashing flange and weep holes; and with accessories as indicated in the floor drain and equipment schedules.
   3. Outlet: Bottom, to match connecting pipe, with NPS 2, NPS 3, NPS 4, or NPS 6 outlet as indicated.

E. Plastic Backwater Valves:
   1. Description: Full-port NPS 3 (DN 80) check valve, PP or PVDF, matching or compatible with system piping and compatible with system liquid, with EPDM seals and flanged ends.
      a. Exception: PVC material for use with PVC piping systems.

F. PP Sink Outlets:
   1. Description: NPS 1-1/2, with clamping device, stopper, and 7-inch high overflow fitting.

2.8 NEUTRALIZATION TANKS
A. Plastic Neutralization Tanks:
   1. Manufacturers:
      a. Chem-Tainer Industries.
      b. IPEX, Inc.
      c. Orion Fittings, Inc.; a division of Watts Water Technologies, Inc.
      d. Schier Products Company.
      e. Sloane, George Fischer, Inc.
      f. Town & Country Plastics, Inc.
      g. Watts Industries (Canada), Inc.
   2. Description: Corrosion-resistant plastic materials; with removable, gastight cover; interior, sidewall, dip-tube inlet; outlet; vent; and threaded or flanged, sidewall pipe connections.
      a. Material: HDPE or ASTM D 4101, or PPASTM D 4101, PP.
      b. Tank Capacity:
      c. Dip Tube: On outlet pipe instead of inlet pipe.
d. Extension: HDPE, PE, or FRPP.
e. Traffic Cover: Heavy-duty pedestrian or light-duty vehicular, gastight, plastic and bolted.
f. Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch diameter.
g. Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and 1- to 3-inch diameter.

2.9 NEUTRALIZATION SYSTEMS

A. Plastic-Tank Neutralization Systems:

1. Manufacturers:
   a. Orion Fittings, Inc.; a division of Watts Water Technologies, Inc.
   b. Town & Country Plastics, Inc.
   c. Burt Processing

2. Description: Automatic system for neutralizing waste.
   a. Controls: Factory-wired and -tested, 120-V ac, to operate probes, control valves, and metering pumps and to monitor pH of effluent; with wiring and electrical-power terminals.
   b. Panel: NEMA 250, Type 4X enclosure, unless otherwise indicated; with manufacturer's standard features, control devices, and indicators, but not less than the following:
      1) Power light and on/off switch.
      2) pH analyzer with meter and high- and low-pH indicators.
      3) Low caustic- and acid-solution level indicators.
      4) Alarm horn with silencer and reset switch.
      5) Agitator running light with on/off switch.
      6) Running lights with on/off switches for caustic- and acid-solution pumps.
   c. Strip chart recorder with capacity for 30-day record.
   d. Piping between Tanks: Same material as chemical-waste piping system unless otherwise indicated.
   e. Interceptor Tank: Same material as mixing tank; with removable, gastight cover; and sidewall inlet and outlet piping connections.
   f. Neutralization Tank: Same material as mixing tank; with removable, gastight cover; sidewall inlet and outlet piping connections; and vent connection in sidewall or top.
   g. Mixing Tank: With removable, gastight cover; sidewall inlet and outlet piping connections; vent connection in sidewall or top; neutralizing-solution piping connections; and openings in top for probe and agitator.
      1) Material: HDPE or ASTM D 4101, PP
      2) pH Probe: Type and length suitable for mixing-tank size.
      3) Agitator: Electric, with stainless-steel shaft and propeller.
   h. Caustic-Solution Storage Tank: PP.
      1) Caustic Chemical: Sodium hydroxide solution.
   i. Acid Storage Tank: PP.
      1) Acid Chemical: Sulfuric acid solution.
j. Metering Pumps: Types suitable for neutralizing solutions.

k. Sampling Tank: Same material as mixing tank; with removable, gastight cover; sidewall inlet and outlet piping connections; and opening in top for probe.

1) pH probe: Type and length suitable for sampling-tank size.

2.10 LEAK-DETECTION SYSTEMS

A. Leak-Detection Systems

1. Manufacturers:
   a. Asahi/America.
   b. Flo Safe, Inc.
   c. Perma-Pipe, Inc.; Subsidiary of MFRI, Inc.
   d. Tyco Thermal Controls LLC; Tracer Div.

2. Description: Cable leak-detection system capable of detecting and annunciating fluid leaks; with controls, panel, wiring, cable sensors, probes if required, and piping.

   a. Annunciator Panel: Enclosure with visual and audible alarms and leak location indicator.

   b. Sensors: Electric cable, suitable for insertion into double-containment piping annular space, with capability of detecting fluid leaks and signaling locations of leaks.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 CONCRETE BASES

A. Anchor neutralization tanks and neutralization system tanks to concrete bases.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 19-inch centers around full perimeter of base.

2. For installed equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be imbedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.

5. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.

6. Use 3000-psi 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete"

7. Comply with requirements in Division 03 for cast-in-place concrete materials and placement.

3.3 PIPING APPLICATIONS

A. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below, unless otherwise indicated.

B. Flanges may be used on aboveground pressure piping, unless otherwise indicated.
C. Aboveground Chemical-Waste Piping: Use the following piping materials for each size range:
   1. NPS 1-1/2 to NPS 6: FRPP drainage piping and [electrofusion] [mechanical] joints.

D. Under Slab-on-Grade, Chemical-Waste Piping: Use the following piping materials for each size range:
   1. NPS 1-1/2 to NPS 6: PP drainage piping and electrofusion joints.

E. Aboveground, Chemical-Waste, Force-Main Piping: Use [any of] the following piping materials for each size range:
   1. NPS 2 to NPS 4: CPVC pipe and threaded fittings, Schedule 80, and threaded joints.
   2. NPS 2 to NPS 4: PP pressure pipe, SDR 11, with socket fittings and heat-fusion joints.

3.4 PIPING INSTALLATION

A. Chemical-Waste Piping Inside the Building:
   1. Install piping next to equipment, accessories, and specialties to allow service and maintenance.
   2. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
   3. Flanges may be used on aboveground piping unless otherwise indicated.
   4. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
   5. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
   6. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
   7. Install piping at indicated slopes.
   8. Install piping free of sags and bends.
   9. Install fittings for changes in direction and branch connections.
   10. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."
   11. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."
   12. Install escutcheons for piping penetrations of walls, ceilings and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."
   13. Verify final equipment locations for roughing-in.

3.5 PIPING SPECIALTY INSTALLATION

A. Embed floor drains in 4-inch minimum depth of concrete around bottom and sides. Comply with requirements in Division 03 Section Miscellaneous Cast-in-Place Concrete" for concrete.

B. Fasten grates to drains if indicated.

C. Set floor drains with tops flush with pavement surface.

D. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use fittings of same material as sewer pipe at branches for cleanouts and riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.
1. Set cleanout bodies in earth in cast-in-place concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding grade. Set cleanout plugs in concrete pavement with tops flush with pavement surface. Comply with requirements in Division 03 Section Miscellaneous Cast-in-Place Concrete* for formwork, reinforcement, and concrete requirements.

E. Install backwater valves in horizontal position. Include riser to cleanout at grade.

3.6 JOINT CONSTRUCTION

A. Chemical-Waste Sewerage Outside the Building:
   1. Plastic-Piping, Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.
   2. Join dissimilar pipe materials with adapters compatible with pipe materials being joined.

B. Chemical-Waste Piping Inside the Building:
   1. Plastic-Piping Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.
   2. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.

3.7 HANGER AND SUPPORT INSTALLATION

A. Pipe sizes in this article refer to aboveground, single-wall piping and carrier piping of containment piping.

B. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

3.8 NEUTRALIZATION TANK INSTALLATION

A. Install collection and neutralization tanks and systems, complete with appurtenances indicated.

   1. Set tops of tank covers flush with finished surface where covers occur in pavements. Set covers 3 inches above finished surface elsewhere unless otherwise indicated.
   2. Include initial fill of limestone for neutralization tanks.

B. Install interior neutralization tanks on smooth and level [concrete base] [floor surface]. Include full initial charge of limestone.

3.9 NEUTRALIZATION SYSTEM INSTALLATION

A. Install neutralization systems on smooth and level concrete base. Include neutralizing solutions and full initial charge of limestone.

3.10 LEAK-DETECTION SYSTEM INSTALLATION


B. Double-Containment Piping: Install leak-detection system in piping annular space.

C. Manholes: Install leak-detection system around bottom of exterior.

D. Install panel in location indicated.
3.11 CONCRETE PLACEMENT
A. Comply with requirements in Division 03 Section "Cast-in-Place Concrete or Miscellaneous Cast-in-Place Concrete" for concrete supports.
B. Place cast-in-place concrete according to ACI 318/318R.

3.12 CONNECTIONS
A. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Make connections to existing piping so finished Work complies as nearly as practical with requirements specified for new Work.
C. Use commercially manufactured wye fittings for sewerage piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
D. Protect existing piping to prevent concrete or debris from entering while making connections. Remove debris or other extraneous material that may accumulate.
E. Install piping adjacent to equipment to allow service and maintenance.

3.13 LABELING AND IDENTIFICATION
A. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for labeling of equipment and piping.
   1. Use detectable warning tape over nonferrous piping and over edges of underground structures.
B. Install labeling and pipe markers on equipment and piping according to requirements in Division 22 Section "Mechanical Identification."
C. Label pressure piping with system operating pressure.

3.14 FIELD QUALITY CONTROL
A. Inspect interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) of backfill is in place and again at completion of Project.
   1. Defects requiring correction include the following:
      a. Alignment: Less than full diameter of inside of pipe is visible between inspection points.
      b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
      c. Crushed, broken, cracked, or otherwise damaged piping.
      d. Hydrostatic Tests for Drainage Piping:
         1) Allowable leakage is a maximum of [50 gal./inch of nominal pipe size per mile] <Insert value> of pipe, during 24-hour period.
         2) Close openings in system and fill with water.
         3) Purge air and refill with water.
         4) Disconnect water supply.
         5) Test and inspect joints for leaks.
Air Tests for Drainage Piping: Comply with UNI-B-6.

2. Leaks and loss in test pressure constitute defects that must be repaired.
3. Submit separate reports for each test.

B. Replace leaking sewerage piping using new materials, and repeat testing until leakage is within allowances specified.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

E. Tests and Inspections:
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect assembled [neutralization systems] [and] [leak-detection systems] and their installation, including piping and electrical connections, and to assist in testing.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Chemical-waste piping will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.15 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service for neutralization system.
1. Complete installation and startup checklists according to manufacturer's written instructions.
2. Neutralization Systems:
   a. Verify that neutralization system is installed and connected according to the Contract Documents.
   b. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 26 Sections.
   c. Install neutralizing solutions and limestone.
   d. Energize circuits.
   e. Start and run systems through complete sequence of operations.
   f. Adjust operating controls.
3. Leak-Detection Systems:
   a. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 26 Sections.
   b. Energize circuits.
   c. Adjust operating controls.
3.16 ADJUSTING
   A. Adjust neutralization-system set points.
   B. Adjust leak-detection-system control and device settings.

3.17 CLEANING
   A. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:
      1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
      2. Clean piping by flushing with potable water.

3.18 DEMONSTRATION
   A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain neutralization systems and leak-detection systems.

END OF SECTION 226600
SECTION 226700 - PROCESSED WATER SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes reagent [deionized] [distilled] [and] [reverse-osmosis]-water piping.

1.2 DEFINITIONS
A. CPVC: Chlorinated polyvinyl chloride plastic.
B. PP: Polypropylene plastic.
C. PTFE: Polytetrafluoroethylene plastic.
D. PVC: Polyvinyl chloride plastic.
E. PVDF: Polyvinylidene fluoride plastic.

1.3 PERFORMANCE REQUIREMENTS
A. Provide components and installation capable of producing piping with the following minimum working-pressure ratings, unless otherwise indicated:
1. Reagent-Water Piping: 50 psig, unless otherwise indicated.
2. Reverse Osmosis and Deionized Water Piping: 50 psig, unless otherwise indicated.

1.4 SUBMITTALS
A. Product Data: For each type of pipe and fitting indicated.
B. Sustainability/Sustainable Submittal:
   1. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
C. Welding certificates.
D. Field quality-control test reports.

1.5 QUALITY ASSURANCE
A. Piping materials shall bear label, stamp, or other markings of specified testing laboratory.
B. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

1.6 DELIVERY, STORAGE, AND HANDLING
A. Do not store plastic pipe and fittings in direct sunlight.
B. Protect pipe and fittings from dirt and damage.
PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Basis of Design: Per the manufacturer listed.
   B. Acceptable Equivalent / Manufacturers as approved by owner, submit as substitution request per Division 1.
   C. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
      1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
      2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 PIPING MATERIALS
   A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.
   B. Transition Fittings: Couplings, flanges, or other manufactured fittings, same size as, with pressure rating at least equal to and ends compatible with piping to be joined.

2.3 PLASTIC PIPE AND FITTINGS
   A. Schedule 80, CPVC Pipe and Fittings: ASTM F 441/F 441M, pipe, with plain ends for solvent-cemented joints with ASTM F 439, socket-type fittings.
   B. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493.
      1. Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
      2. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   C. PP Pipe and Fittings: Made from ASTM D 4101, PP resin.
      1. Manufacturers:
         a. Asahi/America.
         b. Fischer, George, Inc.
         c. IPEX, Inc.
         d. NIBCO, INC.
         e. Orion.
         f. Town & Country Plastics, Inc.
      2. Schedule 40, Pipe and Fittings: Pipe made to ASTM D 2447, Schedule 40 dimensions and socket- or butt-fusion fittings matching pipe Schedule 40 dimensions.
      3. Schedule 80, Pipe and Fittings: Pipe made to ASTM D 2447, Schedule 80 dimensions and socket- or butt-fusion fittings matching pipe Schedule 80 dimensions.
   D. Schedule 80, PVC Pipe and Fittings: ASTM D 1785, pipe, with plain ends for solvent-cemented joints with ASTM D 2467, socket-type fittings.
E. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
   1. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. PVDF Pipe and Fittings: Made from ASTM D 3222, PVDF resin.
   1. Manufacturers:
      a. Asahi/America.
      b. Fischer, George, Inc.
      c. NIBCO, INC.
      d. Orion.
   2. Schedule 40, Pipe and Fittings: Pipe made to ASTM D 2447, Schedule 40 dimensions and socket- or butt-fusion fittings matching pipe Schedule 40 dimensions.
   3. Schedule 80, Pipe and Fittings: Pipe made to ASTM D 2447, Schedule 80 dimensions and socket- or butt-fusion fittings matching pipe Schedule 80 dimensions.

2.4 PLASTIC VALVES

A. CPVC Valves: Made from ASTM D 1784, CPVC compounds.
   1. Ball Valves, NPS 2 and Smaller: MSS SP-122, union type with socket ends and pressure rating not less than 150 psig at 73 deg F (23 deg C).
   2. Butterfly Valves, NPS 3 and Larger: With lever handle and pressure rating not less than 150 psig at 73 deg F.
   3. Check Valves: Swing or ball type with pressure rating not less than 150 psig at 73 deg F.

B. PP Valves: Made from ASTM D 4101, PP resin.
   1. Ball Valves, NPS 2 and Smaller: MSS SP-122, union type with socket ends and pressure rating not less than 150 psig at 73 deg F.
   2. Butterfly Valves, NPS 3 and Larger: With lever handle and pressure rating not less than 150 psig at 73 deg F.
   3. Check Valves: Swing or ball type with pressure rating not less than 150 psig at 73 deg F.

C. PVDF Valves: Made from ASTM D 3222, PVDF resin.
   1. Ball Valves, NPS 2 and Smaller: MSS SP-122, union type with socket ends and pressure rating not less than 150 psig at 73 deg F.
   2. Butterfly Valves, NPS 3 and Larger: With lever handle and pressure rating not less than 150 psig at 73 deg F.
   3. Check Valves: Swing or ball type with pressure rating not less than 150 psig at 73 deg F.

D. PVC Valves: Made from ASTM D 1784, PVC compounds. (SCH 80)
   1. Ball Valves, NPS 2 and Smaller: MSS SP-122, union type with socket ends and pressure rating not less than 150 psig at 73 deg F.
   2. Butterfly Valves, NPS 3 and Larger: With lever handle and pressure rating not less than 150 psig at 73 deg F.
   3. Check Valves: Swing or ball type with pressure rating not less than 150 psig at 73 deg F.
2.5 DIAPHRAGM VALVES
   A. Manufacturers:
      1. Alfa Laval.
      2. Asahi/America.
      3. Engineered Valves; ITT Industries.
      4. Fischer, George Inc.
      5. GEMU Valves, Inc.
      6. Resistoflex Co.
   B. Description: Metal- or plastic-body, diaphragm- or pinch-type valve similar to MSS SP-88 for metal-body diaphragm valves with wetted surfaces coated or lined with plastic material same as, or compatible with, piping material and with 125-psig minimum pressure rating.

2.6 PLASTIC-LINED VALVES
   A. Manufacturers:
      1. Engineered Valves; ITT Industries.
      2. Flowserve Corporation.
      4. Resistoflex Co.
      5. RMB Products.
   B. Ball, Butterfly, Diaphragm, and Plug Valves: Ferrous body with wetted surfaces coated or lined with plastic material same as, or compatible with, piping material and with 150-psig minimum pressure rating.
   C. Check Valves: Ferrous body, ball-check type with wetted surfaces coated or lined with plastic material same as, or compatible with, piping material and with 150-psig minimum pressure rating.

PART 3 - EXECUTION
3.1 PIPING APPLICATIONS
   A. Transition and special fittings with pressure ratings at least equal to and of material same as, or compatible with, piping may be used in applications in this article, unless otherwise indicated.
   B. Reagent-Water and Deionized Water Piping: Use the following piping materials for each size range:
      1. SDR 11 PP pipe and fittings and heat-fusion joints.
   C. Reverse-Osmosis-Water Piping: Use the following piping materials for each size range:
      1. NPS 3 and Smaller: Schedule 40CPVC pipe and fittings and solvent-cemented joints.
      2. NPS 3 and Smaller: Schedule SDR 11 PP pipe and fittings and socket welded joints.
   D. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section “Basic Division 22 Requirements.”
   E. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section ”Basic Division 22 Requirements.”
F. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Basic Division 22 Requirements."

3.2 VALVE APPLICATIONS

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirement apply:
   1. Shutoff Duty: Use ball, diaphragm, or plug valves for NPS 2 and smaller. Use stainless-steel ball, butterfly, diaphragm, or plug valves for NPS 3 and larger.
   2. Throttling Duty: Use ball, diaphragm, or plug valves for NPS 2 and smaller. Use stainless-steel ball, butterfly, diaphragm, or plug valves for NPS 3 and larger.

B. Valves for Reagent-Grade and Deionized Water Piping: Use the following valves for this piping material:
   1. PP Pipe and Fittings: PP wetted-surfaces diaphragm valves. Fused connections for in-line valves, and union connections at equipment connections.

C. Valves for Reverse-Osmosis-Water Piping: Use the following valves for each piping material:
   1. PP Pipe and Fittings: PP plastic ball valves or valves.
   2. CPVC Pipe and Fittings: CPVC plastic ball valves valves.

3.3 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of water piping systems. Location and arrangement of piping layout shall consider design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Refer to Division 22 Section "Basic Division 22 Requirements" for general piping installation requirements.

3.4 JOINT CONSTRUCTION

A. Refer to Division 22 Section "Basic Division 22 Requirements" for basic piping joint construction. Where specific joint construction is not indicated, follow piping manufacturer's written instructions.

B. PP Piping Joints: Make heat-fusion joints similar to procedure in ASTM D 2657 for polyolefin piping joints.

C. Joint dissimilar pipe materials with transition fittings compatible with pipe materials being joined.

3.5 VALVE INSTALLATION

A. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general valve installation requirements.

B. Install sectional valves close to mains on each branch and riser serving equipment.

C. Install shutoff valve on each supply to equipment.

D. Provides 3-valve by-pass arrangements at equipment and points of use.
3.6 HANGER AND SUPPORT INSTALLATION
   A. Pipe hanger and support devices and installation requirements are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
   B. Provide continuous “V” channel hanger systems for PP piping materials and installations.

3.7 CONNECTIONS
   A. Drawings indicate general arrangement of piping, fittings, and specialties.
   B. Install piping adjacent to equipment and machines to allow service and maintenance.
   C. Connect [reagent] [deionized] [distilled] [and] [reverse-osmosis]-water piping to equipment and service outlets with unions or flanges.

3.8 LABELING AND IDENTIFICATION
   A. Install pipe markers and valve tags on piping. Distinguish between different systems and include direction of flow indication on each pipe. Labeling and identification devices are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL
   A. Test new piping and parts of existing piping that have been altered, extended, or repaired, for leaks and defects.
      1. Schedule tests and their inspections with Owner, with at least 48 hours' advance notice.
      2. Do not cover or put into service before inspection and approval.
      3. Test completed piping according to the Owner’s requirements for that particular system. If the Owner does not have published procedures, perform tests as follows to compliment the equipment and intended use:
         a. Hydrostatic Tests: Test piping at pressure not less than 1-1/2 times the maximum system operating pressure, but not less than 100 psig (690 kPa)
      4. Replace leaking joints with new materials and retest until no leaks exist.
      5. Submit separate reports for each test.

3.10 CLEANING
   A. Use procedures prescribed by Owner or, if not prescribed, use procedures described below:
      1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
      2. Clean piping by flushing with system with cleaning chemical such as Hydrogen Peroxide solution and then rinsed thoroughly with intended product water to obtain final required quality at points of use.

END OF SECTION 226700
SECTION 230010 - BASIC DIVISION 23 REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes general administrative, material, and procedural requirements for Division 23 to expand the requirements specified in Division 01.

1.2 REFERENCES
A. See Division 01 Section "References" for acronyms of reference standard.
B. See Contract Document drawings for abbreviations used for this project. In general, abbreviations used for this project follow ASHRAE Fundamentals Handbook Chapter 37 "Abbreviations and Symbols".

1.3 ADMINISTRATIVE REQUIREMENTS
A. Permit and Inspections
   1. Permits: Obtain and pay for all permits, bonds, licenses, tap-in fees, etc., required by the City, State, or other authority having jurisdiction over the work, as part of the work of the affected sections.
   2. Inspections: Arrange and pay for all inspections required by the above when they become due as part of the work of the sections affected. Conceal no work until approved by these governing authorities. Coordinate inspection period with Authorities Having Jurisdiction and Engineer through Construction Manager. Present the Engineer with properly signed certificate of final inspection.
   3. Contractor shall be responsible for submission, registration, and payment of all final inspections to state agencies for mechanical equipment installed as a part of the project work.

B. Coordination
   1. Coordinate facility services as outlined in Division 20 Section "Common Work Results, Division 21 through 28."
   2. Coordinate arrangement, mounting, and support of Division 23 equipment:
      a. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
      b. To provide for ease of disconnecting the equipment with minimum interference to other installations.
      c. To allow right of way for piping and other systems to be installed at required slope.
      d. To assure connections of piping and ductwork will be clear of obstructions and of the working and access space of other equipment.
   3. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
   4. Coordinate location of access panels and doors for items that are behind finished surfaces or otherwise concealed. Install access panel or doors where mechanical equipment requiring service or maintenance is concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames" and Division 23 Section "Basic Mechanical Materials and Methods". Size of access panel shall be such to provide generous accessibility to perform service and maintenance work. Minimum size, unless otherwise approved by Architect, shall be 12 inches x 12 inches.
1.4 SUBMITTAL PROCEDURES

A. General: Provide required submittals in accordance with Division 01 "Submittal Procedures".

B. Definitions:

1. Submittals: A written or graphic expression of the Contractor’s interpretation of requirements in the Contract Documents to show how the Contractor intends to fulfill those requirements. Identify deviations from Contract Documents.

2. Action Submittals: Required submittal which Engineer reviews and approves or takes other appropriate action to communicate to the Contractor the status if the submittal and subsequent action required.

3. Other (Information, Closeout and Maintenance and Material) Submittals: Required submittals which Engineer reviews and may elect to respond. If rejected by Engineer for not complying with requirements, resubmittal or other action may be required on the part of the Contractor.

C. Failure to Submit:

1. Contractor’s failure to provide submittals does not alleviate the responsibility to provide the requirements in the Contract Document as interpreted by the Engineer. Correct non-compliant items.

D. Applicable Information:

1. All information not applicable to the project shall be crossed out in the submittal. All applicable accessories, options, etc., shall be clearly indicated. Failure to comply shall be grounds for the submittal being rejected.

1.5 ACTION SUBMITTALS

A. Submit action submittals in groups by systems. For example, pumps, inlet strainers, and other accessories shall be submitted simultaneously in one package.

B. Submit the following action submittals as qualified in associated Division 23 Sections:

1. Piping Materials.
2. Valves.
3. Expansion Compensation.
5. Supports and Anchors.
7. Vibration and Wind Control.
8. HVAC Insulation.
10. Steam and Condensate Specialties.
12. Refrigerant Specialties.
13. HVAC Pumps.
15. Emergency Generator Exhaust.
16. Feedwater Equipment.
17. Boiler Water Treatment System.
18. Water Treatment.
21. Heating and Cooling Units.
22. Humidifiers.
23. Terminal Units.
25. Air Cleaning.
27. Ductwork Accessories.
28. Sound Attenuators.
29. Diffusers, Registers, and Grilles.
30. Unit Ventilators.
31. Cabinet Unit Heaters.
32. Convector.
33. Fin Tube Radiation.
34. Air Terminals.
35. Control Systems.
36. Sequence of Operation.
37. Testing, Adjusting, and Balancing.

C. Submittals shall include the following:
   1. Product Data: Submit product data, including rated capacities, weights (shipping, installed, and operating), furnished specialties and accessories; and installation and start-up instructions.
   2. Shop Drawings: Submit manufacturer's assembly type shop drawings indicating dimensions, weight loadings, required clearances, methods of assembly of components, and location and size of each field connection.
   3. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to units. Submit manufacturer's ladder type wiring diagrams for control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field installed.
   4. Maintenance Data: Submit maintenance and operating data. Include this data in maintenance manual in accordance with requirements of Division 01.

D. Any specific additional submittal requirements are listed in the applicable specification sections.

E. Action submittals submitted for other than those listed above or specifically required in the appropriate Specification Section will not be reviewed or returned.

F. Contractor Certificates:
   1. Contractor certification forms may be submitted in accordance with Division 01 Section "Submittal Procedures" in lieu of system action submittal product data requirements except for the systems or products listed below:
      a. Boilers.
      b. Chillers.
      c. Cooling Towers.
      d. Air Handling Units.
      e. Instrumentation and Controls for HVAC.
      f. Metal Ductwork.
      g. Pumps.
      h. Fans.
1.6 INFORMATIONAL SUBMITTALS

A. Submit sheet metal field fabrication drawings for all sheetmetal work prior to installation. Provide copies of the accepted sheetmetal fabrication drawings to the other trades. Incorporate in General Coordination Drawings.

B. Coordination Drawings:
   1. Submit general coordination drawings in accordance with Division 01 Section "Project Management Coordination," to a scale of 1/4" = 1'-0" or larger; detailing major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
      a. Indicate the proposed locations of piping, ductwork, equipment, and materials. Include the following:
         1) Clearances for servicing equipment, including coil removal, tube removal, filter removal and space for equipment disassembly required for periodic maintenance.
         2) Exterior wall and foundation penetrations.
         3) Clearances for installing and maintaining insulation.
         4) Fire ratings of walls, ceilings and floors.
         5) Equipment connections and support details.
         6) Sizes and location of required concrete pads and bases.
      b. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
      c. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
      d. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, luminaires, communications systems components, sprinklers, and other ceiling mounted devices.
   2. Submit coordination drawings for entire building.
   3. Submit one set of color plots for review.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:
   1. Provide following file formats for documents indicated below:
      a. Shop / As-Built Drawings (Piping, Ductwork, Equipment): AutoCAD
      b. Operations and Maintenance Manuals, Cutsheets, and other equipment documentation: PDF
   2. Prepare and submit operations and maintenance manuals in accordance with Division 01 Sections "Operation and Maintenance Data" and "Closeout Procedures". In addition to the requirements specified in Division 01, include specific Division 23 Section requirements, and the following general information for equipment items:
      a. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

BASIC DIVISION 23 REQUIREMENTS

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b. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

c. Maintenance procedures for routine preventative maintenance and trouble-shooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

d. Servicing instructions and lubrication charts and schedules.

3. Include the following minimum information in the operations and maintenance manual:

a. Individual characteristics for trouble-shooting sequences for each item of each:
   1) Boiler.
   2) Chiller.
   3) Cooling Tower.
   4) Pump.
   5) Air Handling Unit.
   6) Fan.

b. Catalog cut sheets for every item for which a shop drawing is required.

c. On-hand spare parts list and complete parts list for each:
   1) Pump.
   2) Fan.

d. Approved special construction details that differ from the details shown on Drawings.

e. Permits and inspections certificates.

f. Testing and Commissioning results.

g. Final submittal copy.

h. Special warranty information.

i. Service contract data.

B. Record Documents:

1. Prepare record documents in accordance with the requirements in Division 01 Section "Project Closeout Procedures." In addition to the requirements specified in Division 01, indicate installed conditions for:

a. Ductwork mains and branches, size, and location, for both exterior and interior; locations of balancing, smoke, fire control dampers and other control devices; filters, boxes, terminal units and air terminals requiring periodic maintenance or repair. Dimensioned from two column lines.

b. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located and with items requiring maintenance locate (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Refer to Division 23 Section "Identification for HVAC Piping and Equipment". Indicate actual inverts and horizontal locations of underground piping. Dimensioned from two column lines.

c. Major equipment locations (exposed and concealed), dimensioned from prominent building lines.

d. Contract Modifications and actual equipment and materials installed.

e. Training and demonstration videos.

f. Software CD's.

g. Final field quality control test reports.

h. Record drawings shall be produced from coordination drawings utilizing AutoCAD 2009 and Contract Documents for Schedules and Equipment.

i. Record actual balanced air and water flows (TAB Report).
2. Engage the services of a Land Surveyor or Professional Engineer registered in the state in which the project is located as specified in Division 01 Section "Execution" to record the locations and invert elevations of underground installations.

1.8 MAINTENANCE MATERIAL SUBMITTALS
A. Extra Material:
1. Provide four (4) keys for every different piece of mechanical equipment which is equipped with a lock.
2. Provide all other loose equipment and extra material specified or supplied for use with all systems.

1.9 QUALITY ASSURANCE
A. General: Follow the procedures specified in Division 01 Section "Quality Requirements."
B. Obtain similar products through one source from a single manufacturer.
C. Testing Agency Qualifications: An agency with the experience and capability to conduct the testing indicated and that is acceptable to authorities having jurisdiction.

1.10 DELIVERY, STORAGE, AND HANDLING
A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.
B. Handle equipment carefully to prevent damage, breaking, denting and scoring. Do not install damaged equipment or components; replace with new.
C. Store equipment in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.
D. Comply with Manufacturer's rigging and installation instructions for unloading of equipment and moving of equipment to final location.
E. Any specific additional delivery, storage and handling requirements are listed in the applicable specification sections.

PART 2 - PRODUCTS

2.1 REGULATORY REQUIREMENTS
A. Work and materials shall conform to and be executed, inspected and tested in accordance with the latest edition of applicable Federal, State and local codes and with the other governing rules and regulations of Federal, State, and local governmental agencies.
B. Specific codes and standards which will apply to this installation are listed in applicable specification sections.
C. Other codes and standards which will apply to this installation include the current editions of:
   1. NFPA 54 – National Fuel Gas Code
   2. NFPA 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems
   3. NFPA 90B – Standard for the Installation of Warm Air Heating and Air-Conditioning Systems
   4. NFPA 92 - Standard for Smoke Control Systems
8. ASHRAE Standard 170, Ventilation of Health Care Facilities
9. FGI Guidelines for Design and Construction of Hospitals and Outpatient Facilities
10. Underwriters Laboratories.

D. Where governing codes indicate the Drawings and Specifications do not comply with the minimum requirements of applicable codes, be responsible for either notifying the Architect in writing during the bidding period of the revisions required to meet code requirements, or providing an installation which will comply with the code requirements.

E. U.L. Listing:
1. All electrical equipment, products and materials shall bear the Underwriter's Laboratories (UL), or other approved agency, listing label. Acceptable alternates include:
   b. Wherein an item of equipment is specified to be U.L. Listed, the entire assembly shall be listed by Underwriters Laboratories, Inc. Any modifications to suit the intent of the Specifications shall be performed in accordance with the National Electrical Code and listed by U.L.

2. Definitions:
   a. Listed: Equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation, that maintain periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets appropriate designated standards or has been tested and found suitable for use in a specified manner.
   b. Labeled: Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicated compliance with appropriate standards or performance in a specified manner.

2.2 SUSTAINABILITY CHARACTERISTICS

A. Refer to Division 01 Section "Sustainable Design Requirements." Specific USGBC Sustainability/Sustainable 3.0 project prerequisites and credits related to Division 23 work.

B. Comply with the following Sustainability/Sustainable requirements. Submit documentation of compliance acceptable to USGBC.

1. Sustainability/Sustainable Prerequisite EA 2 requires compliance with ASHRAE/IESNA 90.1 - 2013, in which Section 6.4.4.2.2 – "Duct Leakage Tests" requires leak testing of at least 25 percent of total installed duct area with a pressure class in excess of 3-inch wg (750 Pa). Test all ductwork with a pressure class in excess of 3 inches wg.
   a. Submit Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1 - 2013, Section 6.4.4.2.2 – "Duct Leakage Tests".

BASIC DIVISION 23 REQUIREMENTS
b. Submit Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1 - 2013, Section 6.4.4 – "HVAC System Construction and Insulation".

c. Submit TAB report indicating compliance with ASHRAE 62.1; see Section 7 – "Construction and System Start-up".

2. Sustainability/Sustainable Prerequisite IEQ 1 requires compliance with requirements in ASHRAE 62.1: Follow all applicable requirements in ASHRAE 62.1, Section 5 – “Systems and Equipment” and Section 7 – “Construction and System Start-up”. Air Stream surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

a. Submit Product Data for Prerequisite IEQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 – “Systems and Equipment”.

b. Submit Duct-Cleaning Test Report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 – “Ventilation Systems Start-up”.

3. Submit Data for Credit IEQ 4.1: For adhesives and sealants, documentation shall include printed statement of VOC content.

a. Submit documentation indicating that products comply with the testing and product requirements of the California Department of Health Services’ "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers”.

b. Submit documentation that adhesive has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 MATERIALS

A. Products and the terms materials, equipment, devices, components, assemblies and systems are considered synonymous.

B. All materials, unless otherwise specified, shall be new and be the standard products of the manufacturer. Seconds, rejects, or damaged materials will be rejected.

C. The materials to be provided under these Specifications shall be essentially the standard commercial grade product of the manufacturer. Where two or more units of the same class of equipment are required, these units shall be products of a single manufacturer.

D. The listing of a manufacturer for certain products does not indicate acceptance of a standard or catalogued item of equipment. All products shall conform to the Specifications.

E. All equipment and materials specified shall be products currently in production.

1. If the specified item is not available or is discontinued, a similar product with the same features and functionality shall be provided from the same manufacturer in the newer/upgraded series of product.

2. Equipment and/or devices discovered to be discontinued after submission approval will not be accepted and will require resubmittal for an approved replacement.

F. Product Selection for Restricted Space: Drawings may indicate maximum dimensions for products including clearances between products and adjacent surfaces and other items. Comply with indicated maximum product dimensions.
1. **Assembly Selection:** The Drawings indicate sizes, profiles and dimensional requirements of assembly equipment. Equipment having equal performance characteristics and complying with indicated maximum dimensions and profiles may be considered, provided deviations do not change the design concept intended performance, or code/future extension provision clearances. The burden of proof of equality is on the proposer a minimum of 10 days prior to bid.

G. Include the component parts thereof equipment such as disconnect switches, motor controllers, motors, drives, and guards necessary to the satisfactory and safe operation of the equipment.

2.4 **SOFTWARE PROTECTION**

A. All software supplied with new equipment shall be warranted against leap year program failure.

B. All software supplied with the new equipment shall be warranted against Daylight Savings Time program disruption or failure. Refer to Division 01 Section "Warranties and Supplementary Conditions for Requirements".

C. All software shall be the most current release of the latest available software of the equipment provided.

1. BETA software versions will not be accepted.

**PART 3 - EXECUTION**

3.1 **PREPARATION**

A. General:

1. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

2. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

3. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

4. Right of Way: Give to piping systems installed at a required slope.

B. Manufacturer's Directions and Supervision:

1. Follow all instructions where supervision by a manufacturer is specified. Provide recommended manufacturer and specified field tests, and other recommendations of the manufacturer. The manufacturer shall supervise the installation, connection, start-up, testing, adjustment, instruction of the Owner and final tests of such equipment or system. Where two or more manufacturer's equipment are interrelated, take responsibility to coordinate their work and provide supervision.

2. Have the manufacturer instruct the Owner in the proper operation and maintenance techniques of all equipment, systems, etc., at the time of completion of all work.

C. Rough-In:

1. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

2. Refer to equipment specifications in Divisions 02 through 28 for rough-in requirements.
3.2 INSTALLATION

A. General:
   1. Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment.

B. Locations:
   1. When Drawing details are not available, the Architect shall control the placement of wall and ceiling mounted devices, temperature sensors, and other sensors. The intent is to aesthetically locate devices by providing rough-in hardware, boxes and/or mounting plates, as required, when stud or furring may not be readily available for direct mounting. Consult with Architect's representative for actual placement.
   2. Coordinate mechanical systems, equipment, and materials installation with other building components. Be responsible for any changes in openings and locations necessitated by the equipment installed.
   3. Verify all dimensions by field measurements.
   4. Install systems, materials, and equipment to provide the maximum headroom possible, where mounting heights are not detailed or dimensioned.
   5. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.
   6. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.
   7. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
   8. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
   9. Install HVAC equipment including but not limited to terminal units and other motorized equipment outside of treatment spaces wherever possible.
  10. If installation location will impact access to existing or new equipment including but not limited to control valves, electrical devices, damper actuators, lights, manual valves and other items requiring periodic inspection or maintenance, the Contractor shall notify the Owner in writing a minimum of ten (10) business days before the installation. The Contractor shall not proceed with the installation until receiving written direction from the Owner. Failure to notify the Owner or wait for a written response may result in the work being removed and reinstalled by the Contractor at no additional cost to the Owner.
     a. Upon completion of portions of Work, including work by other Trades, Contractor shall obtain written acceptance of sufficient access to existing or new equipment by Owner. Any Work not deemed to have sufficient access by Owner shall be modified to Owner’s satisfaction at no additional cost to the Owner.
  11. All locations for installation shall conform to manufacturer’s recommended clearances and installation instructions.
  12. The maximum elevation of control valves, electrical devices, damper actuators, lights, manual valves and other items requiring periodic inspection or maintenance shall be located no more than 36 inches above the ceiling assembly whenever possible.
C. Field Coordination:

1. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.
2. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
3. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
4. Protect all equipment and materials from the elements, dirt and other damage from the time it is removed from the point of storage until final acceptance.
5. Include setting equipment to accurate line and grade, leveling equipment, aligning equipment components, providing and installing couplings, bolts, guards, and anchor bolts.
6. Align, level and meet the quality of workmanship subject to manufacturer's installation instructions.
7. Provide all trench and conduit excavation and backfilling required for work inside and outside the building, including repairing of finished surfaces, all required shoring, bracing, pumping, and all protection for safety of persons and property. In addition, check the indicated elevations of the utilities entering and leaving the building. If such elevations require excavations lower than the footing levels, the Architect shall be notified of such conditions and a redesign shall be made before excavations are commenced. Make the excavations at the minimum required depths in order not to undercut the footings.
8. Provide all scaffolding, rigging, hoisting and services necessary for erection and delivery of equipment and apparatus furnished into the premises. These items shall be removed from the premises when no longer required.
9. No mechanical equipment or other work of any kind shall be covered up or hidden from view before it has been examined and approved. Any unsatisfactory work or materials shall be removed and corrected immediately.
10. Coordinate installation of access panel or doors where units are concealed behind finished surfaces.
11. Coordinate connection of new mechanical systems with existing mechanical systems, equipment removals and relocations with the Owner. Perform this work at such times to ensure that periods of shut-down are acceptable to the Owner.
12. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

D. Excavation:

1. Slope sides of excavations to comply with local codes and ordinances. Shore and brace as required for stability of excavation.
2. Shoring and Bracing: Establish requirements for trench shoring and bracing to comply with local codes and authorities. Maintain shoring and bracing in excavations regardless of time period excavations will be open.
   a. Remove shoring and bracing when no longer required. Where sheeting is allowed to remain, cut to of sheeting at an elevation of 30 inches below finished grade elevation.
3. Install sediment and erosion control measures in accordance with local codes and ordinances.
4. Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and form flooding project site and surrounding area.
   a. Do not allow water to accumulate in excavations. Remove water to prevent softening of bearing materials. Provide and maintain dewatering system components necessary to convey water away from excavations.
   b. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey surface water to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.

5. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade and shape stockpiles for proper drainage.
   a. Locate and retain soil materials away from edge of excavations. Do not store within drip-line of trees indicated to remain.
   b. Remove and legally dispose of excess excavated materials and materials not acceptable for use as backfill or fill.

6. Excavation for Underground Vaults and Manholes: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot; plus a sufficient distance to permit placing and removal of concrete formwork, installation of services, other construction and for inspection.
   a. Excavate, by hand, areas within drip-line of large trees. Protect the root system from damage and dry-out. Maintain moist conditions for root system and cover exposed roots with burlap. Paint root cuts of 1 inch in diameter and larger with emulsified asphalt tree paint.
   b. Take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed.

7. Trenching: Excavate trenches for mechanical installations as follows:
   a. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches clearance on both sides of raceways and equipment.
   b. Excavate trenches to depth indicated or required.
   c. Limit the length of open trench to that in which installations can be made and the trench backfilled within the same day.
   d. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of raceways and equipment. Provide a minimum of 6 inches of stone or gravel cushion between rock bearing surface and electrical installations.

8. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35 deg. F (1 deg. C).

9. Backfilling and Filling: Place soil materials in layers to required subgrade elevations for each area classification listed below, using materials specified in Part 2 of this Section.
   a. Under walls and pavements, use a combination of subbase materials and excavated or borrowed materials.
   b. Under building slabs, use drainage fill materials.
   c. Under piping and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation.
d. For piping less than 30 inches below surface of roadways, provide 4 inch thick concrete base slab support. After installation of piping, provide a 4 inch thick concrete encasement (sides and top) prior to backfilling and placement of roadway subbase.

e. Other areas use excavated or borrowed materials.

10. Backfill excavations as promptly as work permits, but not until completion of the following:

a. Inspection, testing, approval and locations of underground utilities have been recorded.


c. Removal of shoring and bracing and backfilling of voids.

d. Removal of trash and debris.

11. Place backfill and fill materials in layers of not more than 8 inches in loose depth for material compacted by heavy equipment and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

12. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification specified below. Do not place backfill or fill material on surfaces that are muddy, frozen or contain frost or ice.

13. Place backfill and fill materials evenly adjacent to structures, piping and equipment to required elevations. Prevent displacement of raceways and equipment by carrying material uniformly around them to approximately same elevation in each lift.

14. Compact soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below.

a. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture density relationship (cohesive soils), determined in accordance with ASTM D 1557 and not less than the following percentages of relative density, determined in accordance with ASTM D 2049, for soils which will not exhibit a well-defined moisture density relationship (cohesionless soils).

1) Areas Under Structures, Building Slabs and Steps, Pavements: Compact top 12 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.

2) Areas Under Walkways: Compact top 6 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.

3) Other Areas: Compact top 6 inches of subgrade and each layer of backfill or fill material to 85 percent maximum density for cohesive soils and 90 percent relative density for cohesionless soils.

b. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water. Apply water in minimum quantity necessary to achieve required moisture content and to prevent water appearing on surface during, or subsequent to, compaction operations.

15. Subsidence: Where subsidence occurs at mechanical installation excavations during the period 12 months after Substantial Completion, remove surface treatment (i.e. pavement, lawn, or other finish), add backfill material, compact to specified conditions, and replace surface treatment. Restore appearance, qualify, and condition of surface of finish to match adjacent areas.
E. Cutting and Patching:

1. General: Perform cutting and patching in accordance with Division 01 Section "Cutting and Patching." In addition to the requirements specified in Division 01, the following requirements apply:

   a. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
      1) Uncover Work to provide for installation of ill-timed Work.
      2) Remove and replace defective Work.
      3) Remove and replace Work not conforming to requirements of the Contract Documents.
      4) Remove samples of installed Work as specified for testing.
      5) Install equipment and materials in existing structures.
      6) Upon written instructions from the Architect, uncover and restore Work to provide for Architect observation of concealed Work.

   b. Cut, remove, and legally dispose of selected mechanical equipment, components, and materials as indicated on Drawings, including all mechanical items made obsolete by the new Work.

   c. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

   d. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

   e. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

   f. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

      1) Refer to Division 01 Section "Quality Requirements" for definition of experience "Installer."

   g. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

      1) Refer to Division 01 Section "Quality Requirements" for definition of experienced "Installer."

F. Painting:

1. Provide the prime painting of all equipment and materials furnished under Division 23 specifications, unless specifically stated otherwise. In general, all equipment except piping and ductwork not provided with a factory-applied final finish shall be delivered to the job site with a shop applied prime coat of paint. Refer to Division 09 Sections "Interior Painting" and "Exterior Painting."

2. All manufacturers' finished equipment surfaces damaged during construction shall be brought to an "as new" condition by touch up or repainting. Any rust shall be completely removed and the surface primed prior to repainting as specified in Division 09.
G. Temporary Use of Equipment
   1. Temporary use of existing or new equipment for Contractor’s convenience shall be authorized in advance by Owner in writing. Contractor shall be responsible for maintaining equipment during such time, including providing filters, periodic filter replacement, cleaning of equipment, ductwork, diffusers, registers, grilles, etc., at the end of construction.

H. Owner-Furnished Equipment
   1. Refer to Division 01.

3.3 INSPECTION
   A. The Contractor shall notify the Owner when the above ceiling rough-in is complete and ready for review by the Owner and Engineer.
   B. The Owner and Engineer shall have five (5) business days following receipt of the notification to perform an inspection of the work.
   C. A list of items to be addressed by the Contractor will be provided within ten (10) days of the initial notification. The list shall be presented to the Contractor in an electronic file format for tracking purposes.
   D. The Contractor shall remediate any issues noted by the Owner and Engineer within the scope of the Contract. The Contractor shall provide the Owner and Engineer an updated issues list with corrective actions taken and date the work was completed.
   E. When all of the issues have been remediated, the Owner and Engineer will review the corrections. Final approval of correction will be provided to the Contractor in writing.
   F. After receipt of written approval from the Owner, the ceiling installation may proceed. Installation of the ceiling before final written approval from the Owner may result in the work being removed and reinstalled by the Contractor at no additional cost to the Owner.

3.4 ADJUSTING
   A. Contractor shall provide software programming changes to match Owner’s final room number designations.
   B. When requested by the Architect, within one (1) year of date of Substantial Completion, provide on-site assistance in reprogramming BMS system or any other software based system to suit actual occupied conditions. Provide up to three (3) 8-hour visits to the site for this purpose.
   C. Room numbers shall match existing/final room numbering plan upon the completion of the project. The room numbers indicated on the Drawings are not necessarily the final room numbers and may be subject to change by the Owner.
   D. All system programming shall be completed to the satisfaction of the Owner. If, after preliminary use of the system and/or training, the increased understanding of the system’s features and capabilities necessitate reprogramming to any extent, reprogramming shall be performed at no additional cost. During the warranty period, this shall include changes to room names and numbers.

END OF SECTION 230010
SECTION 230030 - ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY
A. This section specifies the basic requirements for electrical components which are an integral part of packaged mechanical equipment and variable speed drives. These components include, but are not limited to factory installed motors, starters, and disconnect switches furnished as an integral part of packaged mechanical equipment.
B. Specific electrical requirements (i.e. horsepower and electrical characteristics) for mechanical equipment are scheduled on the Drawings.

1.2 REFERENCES
A. NEMA Standards MG 1: Motors and Generators.
B. NEMA Standard ICS 2: Industrial Control Devices, Controllers, and Assemblies.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS
A. No separate submittal is required. Submit product data for motors, starters, and other electrical components with submittal data required for the equipment for which it serves, as required by the individual equipment specification sections.
B. Provide variable speed drives from a single manufacturer, regardless of manufacturers’ OEM packaging agreements.

1.5 QUALITY ASSURANCE
A. Electrical components and materials shall be UL labeled.
PART 2 - PRODUCTS

2.1 STARTERS, ELECTRICAL DEVICES, AND WIRING

A. Motor Starter Characteristics:
   1. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs, or units in hazardous locations which shall have proper NEMA class and division.
   2. All enclosures installed in parking decks or other areas subject to exposure to salt-spray shall be Type 316 stainless steel.
   3. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.

B. Manual Switches Shall Have:
   1. Pilot lights and extra positions for multi-speed motors.

C. Magnetic Starters:
   1. Maintained contact push buttons and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
   2. Trip-free thermal overload relays, each phase.
   3. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of other Division 23 sections.
   4. Built-in 120 volts control circuit transformer, fused from line side, where service exceeds 240 volts.
   5. Externally operated manual reset.
   6. Under-voltage release or protection.

D. Motor Connections:
   1. Flexible metal conduit, except where plug-in electrical cords are specifically indicated. Liquid-tight flexible metal conduit shall be used in damp or wet locations.

E. Disconnect Switches:
   1. Fusible switches: fused, (Class RK-1) each phase; heavy duty; horsepower rated; non-teasible quick-make, quick-break mechanism; dead front line side shield; solderless lugs suitable for copper or aluminum conductors; spring reinforced fuse clips; electro silver plated current carrying parts; hinged doors; operating lever arranged for locking in the "OPEN" position; arc quenchers; ground wire lug brazed to enclosure; capacity and characteristics as indicated.
   2. Non-Fusible Switches: For equipment 2 horsepower and smaller, shall be horsepower rated; toggle switch type; quantity of poles and voltage rating as indicated. For equipment larger than 2 horsepower, switches shall be the same as fusible type.
   3. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs, or units in hazardous locations which shall have proper NEMA class and division.
   4. Amps Interrupting Capacity (AIC): Match fuse or upstream protection device.
2.2 VARIABLE SPEED DRIVES

A. General: Variable torque AC drive consisting of a solid state adjustable frequency controller (AFC) and a performance matched energy efficient motor. The manufacturer shall provide, coordinate, and start-up the drive package to ensure both proper application of the motor to the controller and to the system. The variable speed drive shall be fully digital pulse with modulation (PWM) utilizing very large scale integration (VLSI) techniques, as well as surface mount technology for increased reliability. The entire VSD Package including all options shall be in one common cabinet with the entire assembly UL approved and listed.

1. The terms adjustable frequency controller (AFC), variable speed drive (VSD) and variable frequency drive (VFD) shall be synonymous.

B. Adjustable Frequency Controller: Shall convert service voltage, three phase, 60 hertz utility power to adjustable voltage/frequency, three phase, AC power for stepless motor control 10 percent to 110 percent of base speed.

C. Designed and constructed to operate within the following service conditions:

1. Elevation: To 3,300 feet without derating.
2. Ambient Temperature Range: 0 degrees C to 40 degrees C.
3. Atmosphere: Non-condensing relative humidity to 95 percent.
4. AC Line Voltage Variation: -10 percent to +10 percent and +/-2 percent frequency.
5. Ride-through power sags up to 500 mSec without a controller trip.

D. AFC shall be selected to be compatible with motor maximum FLA nameplate rating. All components shall be horsepower rated.

E. Circuits shall provide time derivative variable voltage and variable current protection for semiconductors. AFC shall be capable of starting into a rotating load without delay. Protective circuits shall cause instantaneous trip (IET) should any of the following faults occur:

1. 110 percent of controller maximum sine wave current rating is exceeded for longer than one (1) minute.
2. Output phase to phase short circuit condition.
3. Total ground fault protection under any operating condition.
4. High input line voltage.
5. Low input line voltage.
7. External fault (this protective circuit shall permit by means of terminal strip, wiring of remote N.C. safety contacts such as high duct static pressure, fire or smoke safety, etc., to shut down the drive).

F. The following adjustments shall be available in the controller:

1. Maximum Frequency: (15 to 120 Hz) factory set at 60 Hz.
2. Minimum Frequency: (5 to 60 Hz) factory set at 6 Hz.
3. Adjustable Acceleration: (0.1 to 360 seconds) factory set at 20 seconds.
4. Adjustable Deceleration: (0.1 to 360 seconds) factory set at 20 seconds.
5. Volts/Hertz ratio factory set for service voltage at 60 Hz.
6. Voltage offset or boost factory set at 100 percent torque.
7. Current limit (50 percent to 100 percent sine wave current rating) factory set at 100 percent current.
G. Door mounted operator control of AFC shall be furnished with a micro-processor based command center with a membrane keypad which allows auto/manual, start/stop, manual speed control, programming, and visual display of the units operating parameters. The microprocessor system shall be password protected and provide full monitoring, control, and diagnostics.

1. In automatic mode, controller shall follow an external signal and respond to remote start-stop contact wired to terminal strip and all safety interlocks.
2. Digital display shall be door mounted to indicate power on, drive faults, motor running and external faults.
3. While in auto mode the controller shall attempt to three automatic restarts (user selectable) after a power outage, drive fault or external fault. If drive does not successfully come back on line after the programmed tries it shall remain off on IET until operator diagnoses cause of shut down and manually re-establishes drive operation in the bypass (when equipped) or AFC mode of operation.
4. Integral annunciator contact for customer remote indication of drive fault conditions.
5. An integral "External Fault" protective shutdown circuit shall be provided for interface of firestat, smoke detectors, duct high limit pressure switches, etc. These safety interlocks shall provide shutdown of the system while operating the VFD or By-pass mode.
6. Voltage, current and frequency display: Shall be provided to digitally indicate the output voltage, output frequency and output current.
7. Built-in Diagnostics: Shall provide a quick means for monitoring the different signals within the AFC for start-up and troubleshooting. The diagnostics shall indicate internal and external faults and provide digital display of inverter system faults.

H. Input Power Parameters:

1. The variable frequency controller shall accept 208/230 volts AC three phase, 60 Hz for 230V services, and 460 volts AC three phase, 60 Hz for 460 volts series. Variations of up to +/- 10 percent of line voltage and +/-2 Hz of line frequency shall be permitted without the drive shutting down on a fault.
2. The drive input circuitry shall not generate line notches or large voltage transients on the incoming line.

I. Compliance to the Latest Edition of IEEE 519:

1. The VSD manufacturer shall provide calculations, specific to this installation, showing total harmonic voltage distortion is less than 3 percent. Input line filters shall be sized and provided as required by the VSD manufacturer to ensure compliance with the latest edition of IEEE Standard 519, Guide for Harmonic Control and Reactive Compensation for Static Power Converters. The acceptance of this calculation must be completed prior to VSD installation.
2. The VSD manufacturer shall provide drives with load-side line reactors to 3% or better total harmonic distortion when the load-side feeder length is 35 feet or greater.
3. Prior to installation, the VSD manufacturer shall provide the estimated total harmonic distortion (THD) caused by the VSDs. The results shall be based on a computer aided circuit simulation of the total actual system, with information obtained from the power provided and the user.
J. Manual Bypass with Magnetic Contacts:
   1. Manual bypass with magnetic contactors shall provide all the circuitry necessary to safely transfer the motor from the AFC to the power line, or from the line to the controller while the motor is at zero speed.
   2. Two motor contacts, electrically interlocked, shall be utilized. One contactor shall be between the controller output and the motor, controlled by the controller regulator and the other one shall be between the bypass power line and the motor, providing across the line starting. Motor protection is to be provided in both the "controller" mode and the "bypass" mode by a thermal motor overload relay. The control logic shall allow common start/stop and all protective circuit commands in the "controller" mode and the "bypass" mode. A main power input disconnect switch shall be capable of positive shut-down of all input power to both the bypass circuitry and the AFC. This main input disconnect switch shall have provisions for pad locking in the off position for operator safety.
   3. A second input disconnect switch shall allow isolation of the AFC from input power while allowing the system to operate in the bypass mode. This disconnect shall provide the ability to safely troubleshoot and test the controller, both energized and de-energized, while operating in the "bypass" mode. All components shall mount within the common controller enclosure as a factory unitized package.
   4. Provide manual bypass where indicated on the drawings.

K. Enclosure:
   1. Interior: Shall require front access only with both top and bottom cable entry possible and shall be NEMA 1 design.
   2. Exterior or Wet Locations: NEMA Type 4X.

L. Disconnect Switches
   1. General:
      a. Disconnect switches for protection of adjustable frequency drives with engraved coverplate identifying load served.
      b. Disconnect and fuse may be integral to the ASD enclosure or a separate adjacent enclosure.
   2. Manufacturers:
      a. Eaton Corporation; Cutler-Hammer Products.
      b. General Electric Co.; Electrical Distribution & Control Division.
      c. Siemens Energy & Automation, Inc.
      d. Square D/Group Schneider.
   3. Construction:
      a. Heavy duty type, fused and/or non-fusible as shown on Drawings.
      b. Interior Construction: Switch blades fully visible in the off position when the enclosure door is open. Fuseholders for specified fuse, rejection type.
c. Switch Mechanism: Quick make, quick break with positive interlock to prevent opening of enclosure door when operating handle is in the on position and to prevent closing of the switch mechanism with the door open. Operating handle shall be an integral part of enclosure base, have provisions for three padlocks in the off position, and the means to indicate whether the switch is on or off by its position. Vertical operating handles shall be up in the on position.

d. Terminal Lugs: Suitable for quantity of wire to be attached, front removable with terminal shields; mechanical type for copper wire, compression type for aluminum wire.

4. Ratings:
   a. Amperes: 30 - 1200.
   b. Voltage: 240 or 600.
   c. Poles: 2 or 3.
   d. AIC: Match fuse or upstream protective device.
   e. Horsepower Rated: 30 - 600 amps.

5. Enclosure:
   a. Surface mounted type.
   b. Type shall suit area per NEMA requirements.
   c. Ground wire lug of suitable size shall be brazed to the enclosure. Neutral bar on four wire systems shall be ungrounded.
   d. Nameplates on front shall identify load service as well as proper fuse application warning.

M. Cartridge Type Fuses
   1. Manufacturers: Copper Industries, Inc. - Bussmann, Chase-Shawmut, Economy, Littlefuse.
   2. Fuses, General:
      a. General: Provide fuses of types, classes, and current ratings as indicated. Voltage ratings shall be consistent with the circuits on which used.

3. Application of Fuses:
   a. Motor Fused Disconnect Switches and Combination Controllers (AFD bypass combination starters): Class RK1, dual element time delay; LPN-RK, LPS-RK.
   b. AFD short circuit protection; 0 - 600 Amperes: Class RK1, single element fast acting.

N. General options/modifications shall be designed to fit in the standard enclosure while maintaining the AFC UL listing. The complete unit as a total assembly shall be UL approved and labeled.

O. General Options/Modifications shall include:
   1. Isolated Process Control Interface: Shall enable the AFC to follow a 0-5, 1-5, 4-20, 10-50, ma; 0-4, 0-8, 0-10 VDC grounded or ungrounded signal from a process controller.
   2. Input line reactors to provide additional line inductance which reduces nuisance trips from line surges, line notching and voltage distortion. (Refer to compliance with IEEE 519 parameters above).
3. Motor Overload: Shall contain a thermal overload relay designed to protect one AC motor operated on AFC output from extended overload operation. This shall be designed to mount internal to the AFC enclosure.

4. Provide communication card to facilitate communication with the Building Automation System (BAS). All drive parameters shall be available to the BAS through the communication card.

P. Quality Assurance Controls, Procedures, and Tests:

1. Integrated circuits tests shall include 168 hours burn-in screening at 145 degrees C according to MIL-STD-8813B, stabilization baking and temperature cycling from 150 degrees C to -40 degrees C.

2. Small signal semi-conductors shall be lot samples HTRB per MIL-STD-105D (1 percent AGL).

3. All SCR device assemblies of individual heatsink construction shall be electrically curve traced. Each assembly shall be loaded to 125 percent of its rated full load amperes and run for five minutes.

4. Electronic printed circuit board assemblies shall be temperature cycled for 24 hours between 5 degrees C and 85 degrees C.

5. AFC shall be functionally tested under motor load and then cycled under load for several hours.

Q. Manufacturers: Subject to compliance with requirements, provide variable speed drives of one of the following:

1. Asea Brown Boveri (ABB)

PART 3 - EXECUTION

3.1 WIRING

1. All field wiring connections under 120V shall utilize WAGO connectors.

3.2 CLOSEOUT PROCEDURES

A. Provide services of manufacturer's technical representative for one (1) 8-hour day to instruct Owner's personnel in operation and maintenance of variable speed drives.

1. Schedule training with Owner; provide at least seven (7) days' notice to Contractor and Engineer of training date.

END OF SECTION 230030
SECTION 230050 - BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes limited scope general construction materials and methods for application with mechanical installations as follows:
   1. Mechanical equipment nameplate data.
   2. Miscellaneous metals for support of mechanical materials and equipment.
   3. Prime painting of miscellaneous metals and pipe hangers.
   4. Joint sealers for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
   5. Access panels and doors in walls, ceilings, and floors for access to mechanical materials and equipment.

1.2 QUALITY ASSURANCE
A. Installer Qualifications: Engage an experienced Installer for the installation and/or application joint sealers, access panels, and doors.
B. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."
C. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

1.3 SEQUENCE AND SCHEDULING
A. Coordinate the shut-off and disconnection of utility services with the Owner and the utility company.

PART 2 - PRODUCTS

2.1 MECHANICAL EQUIPMENT NAMEPLATE DATA
A. Nameplate: For each piece of power operated mechanical equipment provide a permanent operational data nameplate indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

2.2 MISCELLANEOUS METALS
A. Steel plates, shapes, bars, and bar grating: ASTM A 36.
B. Cold-Formed Steel Tubing: ASTM A 500.
C. Hot-Rolled Steel Tubing: ASTM A 501.
E. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout, recommended for interior and exterior applications.
F. Fasteners: Zinc-coated, type, grade, and class as required.

G. Prime Paint: Refer to Division 09 Section "Painting" for prime paint materials, preparation and application requirements.

2.3 JOINT SEALERS

A. Fire-Resistant Joint Sealers: Refer to Division 07 Sections "Through-Penetration Firestop Systems" and "Fire Resistive Joint Systems" for fire stopping materials to be furnished and installed by Division 23.

2.4 ACCESS DOORS

A. Steel Access Doors and Frames: Refer to Division 08 Section "Access Doors and Frames" for factory-fabricated and assembled access doors.

PART 3 - EXECUTION

3.1 SELECTIVE DEMOLITION

A. Perform demolition operations in accordance with Division 02 Section "Selective Demolition."

3.2 EXCAVATION AND BACKFILLING

A. Perform excavation and backfilling, operations in accordance with Division 31 Section "Earth Moving."

3.3 ERECTION OF METAL SUPPORTS AND ANCHORAGE

A. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

B. Prepare metal and apply one coat of prime paint in accordance with paint manufacturers recommendations and Division 09 Section "Painting." Touch-up shop applied prime paint damaged during final assembly and installation. All rust occurring to metals during storage and installation shall be sand blasted prior to "touch up" painting.

C. Field Welding: Comply with AWS "Structural Welding Code."

D. All exterior steel support and anchorage components shall be hot dipped galvanized.

3.4 APPLICATION OF JOINT SEALERS

A. Install sealant, including forming, packing, and other accessory materials, to fill openings around mechanical services penetrating floors and walls, to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

END OF SECTION 230050
PART 1 - GENERAL

1.1 SUMMARY

A. Provide all labor, materials, facilities, equipment and services to thoroughly clean existing to remain HVAC systems and equipment located as indicated on drawings or as described within this section. The Contractor will provide the estimated dates from start to finish to perform the cleaning services. These HVAC systems and equipment are remaining in use as part of the renovation work of this project.

B. Components requiring cleaning are as indicated on the Drawings.

C. The cleaning work shall include but not be limited to the following components:

1. Air Handling Units or Roof Top Units:
   a. Unit enclosure.
   b. Heating coils.
   c. Cooling coils.
   d. Fan assemblies.
   e. Condensate drain pans.
   f. Replacement of existing filters and/or filter section.
   g. Outside air and return air plenums.
   h. Outside air intakes.

2. Supply and return ductwork, lined and unlined including ductwork plenums, branches, risers, etc.

3. Air outlets and inlets (i.e. supply diffusers, return registers, etc.).

4. Air terminals (i.e. variable and constant volume boxes).

5. Reheat coils (electric or hot water).


7. Exhaust duct systems and associated registers.

8. Exhaust fans and return fans.

9. Fire and fire/smoke dampers.

10. Terminal units (e.g. radiation, unit ventilators, cabinet heaters, fan coil units, etc.).

D. Provide all labor, material, and services to obtain access to HVAC systems to be cleaned including:

1. Removal and reinstalltion of ceiling systems.

2. Installation of new access panels and removal/replacement of existing panels.

3. Cutting and patching of wall and ceiling systems.

4. See Section "Restoration, Repairs, and Installation" for specification on reinstalltion of removed materials.

E. Verify field conditions prior to start of work, to compare site conditions with drawings and/or specifications and to satisfy themselves of conditions existing at the site and all other matters that may be incidental to the work performed under this contract. No extra charge will be allowed for work caused by unfamiliarity with the work area.

F. Repair and replace to match existing materials where damage occurs to HVAC system, including but not limited to:

1. Ductwork and components.
2. Insulation.
3. Pneumatic and electric/electronic control components.

G. Scope of work also includes the following:
1. On the basis of field inspections and review, determine the method of cleaning the HVAC systems and its component to prevent any damage to the system and its operation. Upon completion of the initial inspection, notify the Architect of the proposed methods and their effects to the system.
2. Reset all balancing dampers to original settings if moved during work. Mark original position such that upon final inspection original settings can be field verified.
3. Report to Architect any system defects discovered during the cleaning operation which will require repair or replacement to HVAC systems (e.g. equipment, ductwork, dampers, registers, etc.).

H. Related Sections: The following sections contain requirements that relate to this Section:
1. Other Division 23 sections for ductwork, insulation, filters, dampers.

1.2 DEFINITIONS
A. ASCS: Air System Cleaning Specialist.
C. SMACNA: Sheet Metal and Air Conditioning Contractors’ National Association.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS
A. Provide MSDS sheets on all solvents, cleaners and disinfectants to be used on the project.
B. Provide submittals on any equipment or materials replacing the existing during the remediation process i.e. diffusers, flex, duct, fire dampers.
C. Manufacturer Certificates: Signed by manufacturers certifying that products comply with requirements.
D. Qualification Data: For ASCS.
E. Field quality-control test reports.

1.5 QUALITY ASSURANCE
A. ASCS Qualifications: A certified member of NADCA and shall have at least two years of experience in this field. The Agency shall produce a reference list to the Architect of projects successfully completed of a similar size and scope.
1. Certification: Employ a staff of ASCSs certified by a nationally recognized certification program.
2. Supervisor Qualifications: Certified as an ASCS by NADCA.
3. Experience: Submit records of experience in the field of HVAC systems cleaning.
4. Equipment, Materials, and Labor: Have equipment, materials, and labor required to perform specified services.
B. Comply with current published standards of NADCA.
C. Levels of colony forming units (CFU's) for bacterial, fungus, and mold shall be tested upon completion of the cleaning and sanitizing to assure that post cleaning conditions meet with the NADCA Standards (Unless other standards are prescribed by the Owner or Engineer).

PART 2 - PRODUCTS

2.1 DUCT DEODORIZER
   A. Equal to Madacide, as supplied by Mateson Chemical, EnviroCon as manufactured by Bio-Cide International, Inc., or approved equal.

2.2 SANITIZER
   A. An E.P.A. registered sanitizer "Oxine" as manufactured by Bio-Cide International or approved equal. "BBJ" microbiocide as manufactured by BBJ Chemical Compounds, "Airkem NR Quat" as manufactured by Airkem Industrial Products, or approved equal.

2.3 SURFACE TREATMENTS
   A. A duct liner adhesive coating, Foster 40-10, 40-20 or 40-23, as manufactured by Foster Products Corporation, Cover-Al as manufactured by Mateson Chemical Corporation, or approved equal shall be used. Product shall be a quick setting waterbase adhesive and coating designed for field application to faced or unfaced fiberglass duct liner insulation, or to unfaced fiberboard ductboard insulation. The coating shall dry to form an effective air erosion preventive coating, sealing and reinforcing the surface. The coating shall be resistant to fire, water, oil, grease, bacteria, and fungus.
   B. Mechanical insulation repair coating, Tough Coat, as manufactured by Vac System Industries, Inc., or approved equal shall be used. The coating material shall contain an anti-microbial agent, shall not affect the thermal or acoustic properties of the insulation, and shall conform to NFPA Standards 90A and 90B.

2.4 PLENUM PAINT
   A. Non-Porous Surface: The paint shall be Porta-Sept as manufactured by Porter Paints Inc., Foster 40-26 as manufactured by Foster Products Corporation, or approved equal. Paint shall contain an EPA registered anti-microbial, (Intersept or equal), which inhibits the growth of bacteria, mold, mildew, and fungi.
   B. Porous Surface: The coating shall be Tough-coat as manufactured by Vac Systems Industries or approved equal. Coating shall meet current editions of NFPA Standards 90A and 90B and contain an anti-microbial agent.

2.5 DUCT LINING
   A. To match existing.

2.6 GASKETING
   A. To match existing.
PART 3 - EXECUTION

3.1 PRE-CLEANING PREPARATIONS

A. Prior to start of work, the HVAC system shall be carefully inspected and checked for all conditions affecting the cleaning. Contractor shall verify all access requirements and additional access required to perform the work. Defects shall be reported in writing to the Architect and work shall not proceed until all defects have been documented. Commencement of work shall constitute acceptance of the conditions of the area to which the cleaning work shall be performed and all defects in work resulting from such accepted service will be corrected by this section without additional expense to the Owner. No cleaning shall be performed to ducts where the process has the capacity of damaging the duct lining. The decision to clean and/or encapsulate these areas will be made by the Architect after review of the Contractor’s findings and the Architect has seen the field conditions.

B. Disassemble all removable items as required for access to work area. Store the removables in an approved storage area until the completion of the cleaning work.

C. Fire protection devices (such as smoke detectors, panels, etc.) shall be protected prior to cleaning procedures. They shall be cleaned and tested at the conclusion of work.

D. Coordinate the shutdown and reactivating of the fire alarm system to avoid accidental alarms during cleaning process and related work.

E. The Contractor shall coordinate the shutdown of the air handling equipment with the Owner before starting work, conforming to OSHA requirements regarding fan motor disconnect lock-out/tag-out.

F. Collect samples by gathering the gross debris from the surface of the duct at predetermined locations per system prior to and after cleaning. This shall be accomplished by utilizing protective clean surgical gloves to handle the surface debris. A 100cm² area shall be scraped and the debris placed in a 4 oz. Sterile container with screw cap. The container shall be adequately marked as to sample location, date, and time as a minimum. The NADCA vacuum test is also an accepted method to attain a sample. The total weight will be established per 100cm² area. The material collected shall analyzed for particle characterization, i.e. asbestos, fiberglass, lead. The quantity and species of viable micro-organisms shall be determined by culture methods. Data will be presented as Colony Forming Units (CFUs) and shall be compiled for both bacteria and mold/fungi. Samples and tests shall be performed by independent third party testing. The Contractor and Project Engineer shall conduct inspections to insure that the samples are retrieved at locations that are representative of the ductwork.

3.2 CLEANING

A. Engage a qualified ASCS to clean the following systems:

1. Supply system.
2. Return system.
3. Exhaust system.

B. Perform cleaning before air balancing or mark position of dampers and air-directional mechanical devices before cleaning.
C. Use duct-mounted access doors, as required, for physical and mechanical entry and for inspection.
   1. Install additional duct-mounting access doors to comply with duct cleaning standards. Comply with requirements in Division 23 Section "Air Duct Accessories" for additional duct-mounting access doors.
   2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection. Replace damaged and deteriorated flexible ducts. Comply with requirements in Division 23 Section "Air Duct Accessories" for flexible ducts.
   3. Disconnect and reconnect flexible connectors as needed for cleaning and inspection. Replace flexible connectors. Comply with requirements in Division 23 Section "Air Duct Accessories" for flexible connectors.
   4. Replace damaged fusible links on fire and smoke dampers. Replacement fusible links shall be same rating as those being replaced. Comply with requirements in Division 23 Section "Air Duct Accessories" for fusible links.
   5. Remove and reinstall ceiling components to gain access for duct cleaning. Clean ceiling components after they have been removed and replaced.

D. Mark position of dampers and air-directional mechanical devices before cleaning, and restore to their marked position on completion.

E. Particulate Collection and Odor Control:
   1. Where venting vacuuming system inside building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron size (or greater) particles.
   2. When venting vacuuming system outside building, use filtration to contain debris removed from the HVAC system and locate exhaust down wind and away from air intakes and other points of entry into building.

F. Clean the following metal-duct system components by removing visible surface contaminants and deposits:
   1. Air outlets and inlets (registers, grilles, and diffusers).
   2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
   3. Air-handling-unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
   5. Return-air ducts, dampers, and actuators, except in ceiling plenums and mechanical room.
   6. Supply-air ducts, dampers, actuators, turning vanes, induction units, terminal units, and air terminals (i.e. variable and constant volume boxes).
   7. Dedicated exhaust and ventilation components.

G. Mechanical Cleaning Methodology:
   1. Clean metal-duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
   2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of ducts so areas being cleaned are under negative pressure.
   3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts or duct liner.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment, and do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

6. Provide operative drainage system for washdown procedures.

7. Biocidal Agents and Coatings: Apply biocidal agents if fungus is present; use according to manufacturer's written instructions after removal of surface deposits and debris.

H. Cleanliness Verification:
   1. Verify cleanliness after mechanical cleaning and before application of treatment, including biocidal agents and protective coatings.
   2. Visually inspect metal-duct systems for contaminants.
   3. Where contaminants are discovered, reclean and reinspect duct systems.

3.3 DUCT ACCESSORIES INSTALLATION

A. Install duct accessories according to applicable details in the current edition of SMACNA's "HVAC Duct Construction Standards—Metal and Flexible" for metal ducts.

B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install duct-mounting access doors where access doors do not currently exist to allow for the cleaning of ducts, accessories, and terminal units as follows:
   1. On both sides of duct coils.
   2. Downstream from volume dampers, turning vanes, and equipment.
   3. Adjacent to fire or smoke dampers; reset or install new fusible links.
   4. Before and after each change in direction, at maximum 50-foot (15-m) spacing.
   5. On sides of ducts where adequate clearance is available.

D. Install the following sizes for duct-mounting, rectangular access doors, subject to duct size:
   1. One-Hand or Inspection Access: 18 by 18 inches.
   3. Head and Hand Access: 18 by 18 inches.

E. Install the following sizes for duct-mounting, round access doors, subject to duct size:
   1. One-Hand or Inspection Access: 20 inches (510 mm) in diameter.
   2. Two-Hand Access: 20 inches (510 mm) in diameter.
   3. Head and Hand Access: 20 inches (510 mm) in diameter.
   4. Head and Shoulders Access: 20 inches (510 mm) in diameter.

3.4 CONNECTIONS

A. Reconnect ducts to fans and air-handling units with existing flexible connectors after cleaning ducts and flexible connectors. Replace existing damaged and deteriorated flexible connectors.
B. For fans developing static pressures of 5-inch wg (1250 Pa) and higher, cover replacement flexible connectors with loaded vinyl sheet held in place with metal straps.

C. Reconnect terminal units to supply ducts with existing flexible ducts or replace damaged and deteriorated existing flexible ducts with maximum 12-inch (300-mm) lengths of new flexible duct.

D. Reconnect diffusers or light troffer boots to low-pressure ducts with existing flexible ducts or replace damaged and deteriorated existing flexible ducts with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.

E. Reconnect existing and new flexible ducts to metal ducts with draw bands.

3.5 FIELD QUALITY CONTROL

A. Gravimetric Analysis: Sections of metal-duct system, four locations chosen randomly by Owner, may be tested for cleanliness according to NADCA vacuum test gravimetric analysis.

1. If analysis determines that levels of debris are equal to or lower than suitable levels, system shall have passed cleanliness verification.
2. If analysis determines that levels of debris exceed suitable levels, system cleanliness verification will have failed and metal-duct system shall be recleaned and reverified.

B. Verification of Coil Cleaning: Cleaning shall restore coil pressure drop to within 10 percent of pressure drop measured when coil was first installed. If original pressure drop is not known, coil will be considered clean only if it is free of foreign matter and chemical residue, based on thorough visual inspection.

C. Report results of tests in writing.

3.6 SEQUENCE OF WORK

A. The Air Conveyance Systems to be cleaned are usually required to remain running and operational during the normal work hours. The Contractor shall submit a procedure and schedule for cleaning the ductwork and installing filters which will minimize contamination of already cleaned areas. This schedule shall be approved by the Owner prior to starting work.

3.7 SANITIZATION

A. If microbial contamination is found during the Precleaning Preparation (Refer to Section 3.1):

1. A sanitizing agent shall be applied to all (metal only) supply and return air ductwork cleaned as part of this project. Application and operation shall be as per manufacturer's recommendations.

3.8 RESTORATION, REPAIRS, AND INSTALLATION

A. Repair and restore space in accordance with the final inspection list specified herein. If no additional notification of the work space is to take place, reinstall all removable equipment and fixtures back in the space.

B. Any damage to the finishes, floor, walls or any other item or fixture that has been the result of actions by the cleaning agency's personnel shall be repaired to their original condition without any additional costs.

C. Reinstall existing and install new accessories in accordance with manufacturer's instructions and other Division 23 Sections.
D. Demonstrate re-setting of fire and balancing dampers to authorities having jurisdiction and Owner's representative.

E. Provide duct access doors for inspection and cleaning before and after filters, coils, fan, automatic dampers at fire dampers, and elsewhere as required. Provide suitable size access doors for hand access or shoulder access where necessary.

F. Reconnect terminal boxes to ducts. Replace flexible ducts, clamps and gasketing if damaged during removal.

G. Reconnect diffusers to ducts, replace straps or clamps and flexible duct if damaged during removal.

H. Repair or replace duct insulation damaged during the work. Materials to match existing.

3.9 FINAL REPORT

A. Submit final report to the Architect outlining the conditions and work completed on each HVAC System.

B. The report shall contain a tabulation of the vacuum tests taken before and after the cleaning process.

C. The report shall contain the findings of tests performed on the debris collected with the ACS (i.e. the composition of the material).

D. The report shall contain photographic or video documentation of representative areas of the ductwork systems cleaned as part of the project. This photo documentation shall show both before and after pictures verifying visual inspection.

END OF SECTION 230130
SECTION 230131 - HVAC AIR-DISTRIBUTION SYSTEM CLEANING

PART 1 - GENERAL

1.1 SUMMARY
A. Section includes cleaning HVAC air-distribution equipment, ducts, plenums, and system components.

1.2 DEFINITIONS
A. ASCS: Air systems cleaning specialist.

1.3 SUBMITTALS
A. Qualification Data: For an ASCS.
B. Strategies and procedures plan.
C. Cleanliness verification report.

1.4 QUALITY ASSURANCE
A. ASCS Qualifications: A certified member of NADCA.
   1. Supervisor Qualifications: Certified as an ASCS by NADCA.
B. UL Compliance: Comply with UL 181 and UL 181A for fibrous-glass ducts.
C. Cleaning Conference: Conduct conference at Froedtert Hospital.
   1. Review methods and procedures related to HVAC air-distribution system cleaning including, but not limited to, review of the cleaning strategies and procedures plan.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine HVAC air-distribution equipment, ducts, plenums, and system components to determine appropriate methods, tools, and equipment required for performance of the Work.
B. Perform “Project Evaluation and Recommendation” according to NADCA ACR 2006.
C. Prepare written report listing conditions detrimental to performance of the Work.
D. Proceed with work only after unsatisfactory conditions have been corrected.

3.2 PREPARATION
A. Prepare a written plan that includes strategies and step-by-step procedures. At a minimum, include the following:
   1. Supervisor contact information.
   2. Work schedule including location, times, and impact on occupied areas.
   3. Methods and materials planned for each HVAC component type.
   4. Required support from other trades.
5. Equipment and material storage requirements.
6. Exhaust equipment setup locations.

B. Use the existing service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry and for inspection.


3.3 CLEANING

A. Comply with NADCA ACR 2006.

B. Remove visible surface contaminants and deposits from within the HVAC system.

C. Systems and Components to Be Cleaned:
   1. Air devices for supply and return air.
   2. Air-terminal units.
   3. Ductwork:
      a. Supply-air ducts, including turning vanes and reheat coils, to the air-handling unit.
      b. Return-air ducts to the air-handling unit.
      c. Exhaust-air ducts.

4. Air-Handling Units:
   a. Interior surfaces of the unit casing.
   b. Coil surfaces compartment.
   c. Condensate drain pans.
   d. Fans, fan blades, and fan housings.

5. Filters and filter housings.

D. Collect debris removed during cleaning. Ensure that debris is not dispersed outside the HVAC system during the cleaning process.

E. Particulate Collection:
   1. For particulate collection equipment, include adequate filtration to contain debris removed. Locate equipment downwind and away from all air intakes and other points of entry into the building.
   2. HEPA filtration with 99.97 percent collection efficiency for particles sized 0.3 micrometer or larger shall be used where the particulate collection equipment is exhausting inside the building.

F. Control odors and mist vapors during the cleaning and restoration process.

G. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning. Restore them to their marked position on completion of cleaning.

H. System components shall be cleaned so that all HVAC system components are visibly clean. On completion, all components must be returned to those settings recorded just prior to cleaning operations.

I. Clean all air-distribution devices, registers, grilles, and diffusers.

J. Clean visible surface contamination deposits according to NADCA ACR 2006 and the following:
   1. Clean air-handling units, airstream surfaces, components, condensate collectors, and drains.
2. Ensure that a suitable operative drainage system is in place prior to beginning wash-down procedures.
3. Clean evaporator coils, reheat coils, and other airstream components.

K. Duct Systems:
1. Create service openings in the HVAC system as necessary to accommodate cleaning.
2. Mechanically clean duct systems specified to remove all visible contaminants so that the systems are capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).

L. Debris removed from the HVAC system shall be disposed of according to applicable Federal, state, and local requirements.

M. Mechanical Cleaning Methodology:
1. Source-Removal Cleaning Methods: The HVAC system shall be cleaned using source-removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and to safely remove these contaminants from the facility. No cleaning method, or combination of methods, shall be used that could potentially damage components of the HVAC system or negatively alter the integrity of the system.
   a. Use continuously operating vacuum-collection devices to keep each section being cleaned under negative pressure.
   b. Cleaning methods that require mechanical agitation devices to dislodge debris that is adhered to interior surfaces of HVAC system components shall be equipped to safely remove these devices. Cleaning methods shall not damage the integrity of HVAC system components or damage porous surface materials such as duct and plenum liners.

2. Cleaning Mineral-Fiber Insulation Components:
   a. Fibrous-glass thermal or acoustical insulation elements present in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment while the HVAC system is under constant negative pressure and shall not be permitted to get wet according to NADCA ACR 2006.
   b. Cleaning methods used shall not cause damage to fibrous-glass components and will render the system capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).
   c. Fibrous materials that become wet shall be discarded and replaced.

N. Coil Cleaning:
1. Measure static-pressure differential across each coil.
2. See NADCA ACR 2006, "Coil Surface Cleaning" Section. Type 1, or Type 1 and Type 2, cleaning methods shall be used to render the coil visibly clean and capable of passing Coil Cleaning Verification (see applicable NADCA ACR 2006).
3. Coil drain pans shall be subject to NADCA ACR 2006, "Non-Porous Surfaces Cleaning Verification." Ensure that condensate drain pans are operational.
4. Electric-resistance coils shall be de-energized, locked out, and tagged before cleaning.
5. Cleaning methods shall not cause any appreciable damage to, cause displacement of, inhibit heat transfer, or cause erosion of the coil surface or fins, and shall comply with coil manufacturer's written recommendations when available.
6. Rinse thoroughly with clean water to remove any latent residues.
O. Antimicrobial Agents and Coatings:
   1. Apply antimicrobial agents and coatings if active fungal growth is reasonably suspected or where unacceptable levels of fungal contamination have been verified. Apply antimicrobial agents and coatings according to manufacturer’s written recommendations and EPA registration listing after the removal of surface deposits and debris.
   2. When used, antimicrobial treatments and coatings shall be applied after the system is rendered clean.
   3. Apply antimicrobial agents and coatings directly onto surfaces of interior ductwork.
   4. Sanitizing agent products shall be registered by the EPA as specifically intended for use in HVAC systems and ductwork.

3.4 CLEANLINESS VERIFICATION
A. Verify cleanliness according to NADCA ACR 2006, "Verification of HVAC System Cleanliness" Section.
B. Verify HVAC system cleanliness after mechanical cleaning and before applying any treatment or introducing any treatment-related substance to the HVAC system, including biocidal agents and coatings.
C. Perform visual inspection for cleanliness. If no contaminants are evident through visual inspection, the HVAC system shall be considered clean. If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection for cleanliness.
D. Additional Verification:
   1. Perform surface comparison testing or NADCA vacuum test.
   2. Conduct NADCA vacuum gravimetric test analysis for nonporous surfaces.
E. Verification of Coil Cleaning:
   1. Measure static-pressure differential across each coil.
   2. Coil will be considered clean if cleaning restored the coil static-pressure differential within 10 percent of the differential measured when the coil was first installed.
   3. Coil will be considered clean if the coil is free of foreign matter and chemical residue, based on a thorough visual inspection.
F. Prepare a written cleanliness verification report. At a minimum, include the following:
   1. Written documentation of the success of the cleaning.
   2. Site inspection reports, initialed by supervisor, including notation on areas of inspection, as verified through visual inspection.
   3. Surface comparison test results if required.
   4. Gravimetric analysis (nonporous surfaces only).
   5. System areas found to be damaged.
G. Photographic Documentation: Comply with requirements in Division 01 Section "Photographic Documentation."

3.5 RESTORATION
A. Restore and repair HVAC air-distribution equipment, ducts, plenums, and components according to NADCA ACR 2006, "Restoration and Repair of Mechanical Systems" Section.
B. Restore service openings capable of future reopening. Comply with requirements in Division 23 Section "Metal Ducts." Include location of service openings in Project closeout report.
C. Replace fibrous-glass materials that cannot be restored by cleaning or resurfacing. Comply with requirements in Division 23 Sections "Metal Ducts."

D. Replace damaged insulation according to Division 23 Section "HVAC Insulation."

E. Ensure that closures do not hinder or alter airflow.

F. New closure materials, including insulation, shall match opened materials and shall have removable closure panels fitted with gaskets and fasteners.

G. Reseal fibrous-glass ducts. Comply with requirements in Division 23 Section "Nonmetal Ducts."

END OF SECTION 230131
SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY
A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on AC power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 COORDINATION
A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   1. Motor controllers.
   2. Torque, speed, and horsepower requirements of the load.
   3. Ratings and characteristics of supply circuit and required control sequence.
   4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS
A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
B. Comply with NEMA MG 1 unless otherwise indicated.
C. Comply with IEEE 841 for severe-duty motors.

2.2 MANUFACTURERS
A. Acceptable manufacturers:
   1. Baldor
   2. General Electric
   3. Gould
   4. Lincoln
   5. MagneTek/Century
   6. Marathon
   7. Reliance
   8. Siemens
   9. Toshiba
   10. U.S. Motors
   11. Westinghouse

2.3 MOTOR CHARACTERISTICS
A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
2.4 POLYPHASE MOTORS
A. Description: NEMA MG 1, Design B, medium induction motor.
B. Efficiency: Premium efficiency, as defined in NEMA MG 1.
C. Service Factor: 1.15.
D. Multispeed Motors: Separate winding for each speed.
F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
G. Enclosure:
   1. Provide total-enclosed, fan-cooled (TEFC) enclosures for motors installed outside, in roof mounted equipment or exposed to environments with relative humidity exceeding 60% for more than 5 hours per annum.
   2. Open, drip proof (ODP) motors for all other applications.
H. Temperature Rise: One class below associated insulation rating class.
I. Insulation: Class F.
J. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.5 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS
A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
B. Motors Used with Variable Speed Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   3. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
   4. Shaft Grounding: All motors operated on variable frequency drives shall be equipped with a maintenance free, conductive micro fiber, shaft grounding ring with a minimum of two rows of circumferential micro fibers to discharge electrical shaft currents within the motor and/or its bearings. Motors up to 100 HP shall be provided with a minimum of one shaft grounding ring installed either on the drive end or non-drive end. Motors over 100 HP shall be provided with an insulated bearing on the non-drive end and a shaft grounding ring on the drive end of the motor. Grounding rings shall be provided and installed by the motor manufacturer or contractor and shall be installed in accordance with the manufacturer's recommendations. Shaft grounding bearing protection ring shall be AEGIS Model SGR.
C. Severe-Duty Motors: Comply with current edition of IEEE 841, with 1.15 minimum service factor.
D. Efficiency:

1. Motors which are 3-phase and 1 hp or larger (nonhermetic) must be NEMA design B and meet the following premium levels of nominal efficiency at full load. The motors must be tested in accordance with IEEE Standard 112 test method B and NEMA MG-1-12-53A.

2. Minimum Motor Efficiencies:

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<th>Motor Size (HP)</th>
<th>Speed (RPM)</th>
<th>OPEN DRIP-PROOF (ODP)</th>
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2.6 STANDARD SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.
E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.7 ELECTRICALLY COMMUTATED (ECM) SINGLE PHASE MOTORS

A. Equipment serving critical areas shall not be provided with ECM motors, unless redundant equipment is provided. The contractor shall provide equipment with an induction motor and variable speed drive.

B. Motor assembly shall be designed for use on direct drive centrifugal fans or pumps. Motors shall be ECM, variable-speed, DC, brushless motors specifically designed for use with single phase, 277 volt (or 120 volt), 60 hertz electrical input. Motor shall be complete with and operated by a single-phase integrated controller/inverter that operates the wound stator and senses rotor position to electronically commutate the stator. All motors shall be designed for synchronous rotation. Motor rotor shall be permanent magnet type with near zero rotor losses. Motor shall have built-in soft start and soft speed change ramps. Motor shall be able to be mounted with shaft in horizontal or vertical orientation. Motor shall be permanently lubricated with ball bearings. Motor shall be direct coupled to the fan blower or pump. Motor shall maintain a minimum of 70 percent efficiency over its entire operating range. Provide both manual and remote speed control for adjustment of the fan airflow or pump water flow setpoint. Inductors shall be provided to minimize harmonic distortion and line noise. Motor shall be designed to overcome reverse rotation without affecting life expectancy.

C. Motor manufacturer shall provide a factory installed PWM controller for manual and remote controlled speed adjustment. The manual PWM controller shall be field adjustable with a standard screwdriver. The PWM controller shall also be capable of receiving a 0-10 Vdc signal from the DDC controller to control the fan or pump speed. When the manual PWM controller is used, the factory shall preset the speed for air or water flow as shown on the equipment schedules.

D. The ECM Programming Process shall be iterative process of developing constants for the ECM motor to operate at the optimum efficiency and provide pressure independent air or water flow.

E. The minimum and maximum fan or pump curves shall be determined based on minimum and maximum rpm of the ECM motor. The motor manufacturer interface unit plots rpm versus torque of the motor and determines the difference between measured vented CFM and the ECM calculated CFM equals zero. Once the CFM difference is zero, or as close to zero as possible, the ECM constants are saved for that unit’s airflow characteristics.

1. The remote PWM voltage signal shall be calibrated to provide 100 percent flow at full voltage (10.0V) and minimum flow at minimum voltage (1.0V). The calibrated PWM controller shall allow the ECM motor to operate with remote signal to ensure pressure independent operation of the motor with any DDC controller.

2. Controller shall also provide manual controlled PWM signal using two on-board potentiometers.

F. ECM Programming Process extends from the lab to the ISO 9001:2000 certified factories where individual ECM motors are programmed with the appropriate ECM program for each order.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513
PART 1 - GENERAL

1.1 SUMMARY
A. Section Includes:
1. Expansion compensators.
2. Flexible-hose expansion joints.
3. Pipe bends and loops.
4. Alignment guides and anchors.

1.2 DEFINITIONS
A. BR: Butyl rubber.
B. Buna-N: Nitrile rubber.
C. CR: Chlorosulfonated polyethylene synthetic rubber.
D. CSM: Chlorosulfonyl-polyethylene rubber.
E. EPDM: Ethylene-propylene-diene terpolymer rubber.
F. NR: Natural rubber.
G. PTFE: Polytetrafluoroethylene plastic.

1.3 PERFORMANCE REQUIREMENTS
A. Compatibility: Products shall be suitable for piping system fluids, materials, working pressures, and temperatures.
B. Capability: Products shall absorb 200 percent of maximum axial movement between anchors.

1.4 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.5 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.
B. Certification Letters: For each type of pipe expansion joint, signed by product manufacturer.
C. Delegated Design Services: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and bends.
   2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
   3. Alignment Guide Details: Detail field assembly and attachment to building structure.
   4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
1.6 INFORMATIONAL SUBMITTALS
A. Qualification Data:
   1. Installer Qualifications.
   2. Welding Certificates.

1.7 CLOSEOUT SUBMITTALS
A. Maintenance Data: For pipe expansion joints to include in maintenance manuals.

1.8 QUALITY ASSURANCE
A. Welding Qualifications: Qualify procedures and personnel according to the following:

PART 2 - PRODUCTS
2.1 EXPANSION JOINTS
A. Expansion Compensators: Double-ply corrugated steel, stainless-steel, or copper-alloy bellows in a housing with internal guides, anti-torque device, and removable end clip for positioning.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hyspan Precision Products, Inc.
      b. Metraflex, Inc.
      c. Unaflex, Inc.
   2. Minimum Pressure Rating: 175 psig (1200 kPa), unless otherwise indicated.
   3. Configuration for Copper Piping: Two-ply phosphor-bronze or stainless-steel bellows and bronze or stainless-steel shroud.
   5. End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint or threaded.
   6. End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
   7. End Connections for Steel Pipe NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged.

B. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Flex-Hose Co., Inc.
      b. Flexicraft Industries.
      c. Flex-Pression, Ltd.
      d. Metraflex, Inc.
2. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder-joint end connections.
   a. NPS 2 (DN 50) and Smaller: Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 340 psig at 450 deg F (2340 kPa at 232 deg C) ratings.
   b. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F (2070 kPa at 21 deg C) and 225 psig at 450 deg F (1550 kPa at 232 deg C) ratings.

3. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder-joint end connections.
   a. NPS 2 (DN 50) and Smaller: Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 500 psig at 450 deg F (3450 kPa at 232 deg C) ratings.
   b. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F (2890 kPa at 21 deg C) and 315 psig at 450 deg F (2170 kPa at 232 deg C) ratings.

4. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 (DN 50) and smaller and flanged end connections for NPS 2-1/2 (DN 65) and larger.
   a. NPS 2 (DN 50) and Smaller: Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.
   b. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F (1380 kPa at 21 deg C) and 145 psig at 600 deg F (1000 kPa at 315 deg C) ratings.
   c. NPS 8 to NPS 12 (DN 200 to DN 300): Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F (860 kPa at 21 deg C) and 90 psig at 600 deg F (625 kPa at 315 deg C) ratings.

5. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 (DN 50) and smaller and flanged end connections for NPS 2-1/2 (DN 65) and larger.
   a. NPS 2 (DN 50) and Smaller: Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 515 psig at 600 deg F (3550 kPa at 315 deg C) ratings.
   b. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F (1900 kPa at 21 deg C) and 200 psig at 600 deg F (1380 kPa at 315 deg C) ratings.
   c. NPS 8 (DN 200) and Larger: Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.

2.2 ALIGNMENT GUIDES
   A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Flex-Hose Co., Inc. or comparable product by one of the following:
2.3 MATERIALS FOR ANCHORS

A. Steel Shapes and Plates: ASTM A 36/A 36M.
B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.
C. Washers: ASTM F 844, steel, plain, flat washers.
D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.
   2. Expansion Plug: Zinc-coated steel.
E. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.
   1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
F. Concrete: Portland cement mix, 3000 psi (20.7 MPa) minimum. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.
G. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink, nonmetallic grout; suitable for interior and exterior applications.
   2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

A. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
B. Install expansion joints of sizes matching size of piping in which they are installed.
C. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

3.2 PIPE BEND AND LOOP INSTALLATION

A. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
B. Attach pipe bends and loops to anchors.
2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer’s written instructions.

C. Provide di-electric flanges or couplers at interface between dis-similar metals.

3.3 SWING CONNECTIONS

A. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

3.4 ALIGNMENT-GUIDE INSTALLATION

A. Install guides on piping adjoining pipe expansion fittings and loops.

B. Attach guides to pipe and secure to building structure.

3.5 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion-joint manufacturer’s written instructions if expansion joints or compensators are indicated.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

END OF SECTION 230516
SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY
A. Section Includes:
   1. Sleeves.
   2. Stack-sleeve fittings.
   3. Sleeve-seal systems.
   4. Sleeve-seal fittings.
   5. Grout.

1.2 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES
A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
F. Molded-PE or PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
G. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with setscrews.
2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Metraflex Company (The).
   2. GPT Industries
   3. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
   1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Stainless steel.
   3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the
   1. Presealed Systems.

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT


B. Characteristics: Nonshrink; for interior and exterior applications.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) annular clear space between piping and concrete slabs and walls.
   1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
   2. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level.
3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."

E. Fire-BARRIER Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.
   1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
   2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Division 07 Section "Sheet Metal Flashing and Trim."
   3. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.
   4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-BARRIER Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.
3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves.
   b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-pipe sleeves.

2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves with sleeve-seal system or Galvanized-steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:
   a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves with sleeve-seal system or Galvanized-steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:
   a. Piping Smaller Than NPS 6 (DN 150): Galvanized-steel-pipe sleeves, PVC-pipe sleeves or Molded-PVC sleeves.
   b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-pipe sleeves, PVC-pipe sleeves or Stack-sleeve fittings.

5. Interior Partitions:
   b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION 230517
SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY
   A. Section Includes:
      1. Escutcheons.
      2. Floor plates.

1.2 SUBMITTALS
   A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS
   A. One-Piece, Cast-Brass Type: With polished, chrome-plated and rough-brass finish and setscrew fastener.
   B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
   C. Split-Casting Brass Type: With polished, chrome-plated and rough-brass finish and with concealed hinge and setscrew.
   D. One-Piece, Stamped-Steel Type: With set screw and chrome-plated finish.
   E. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw, and chrome-plated finish.

2.2 FLOOR PLATES
   A. One-Piece Floor Plates: Cast-iron flange.
   B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
   B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
      1. Escutcheons for New Piping:
         a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
         b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
         c. Insulated Piping: One-piece, stamped-steel type with spring clips.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.

e. Bare Piping in Unfinished Service Spaces: Split-casting brass type with polished, chrome-plated finish.

f. Bare Piping in Equipment Rooms: Split-casting brass type with rough-brass finish.

g. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

2. Escutcheons for Existing Piping:

a. Insulated Piping: One-piece, stamped-steel type with spring clips.

b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.

c. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.

d. Bare Piping in Unfinished Service Spaces: Split-casting brass type with rough-brass finish.

e. Bare Piping in Equipment Rooms: Split-casting brass type with rough-brass finish.

f. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.

2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 230518
SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY
   A. Section Includes:
      1. Thermometers.
      2. Pressure gages.
      3. Test plugs.
      4. Flowmeters.
      5. Thermal-energy meters.

1.2 DEFINITIONS
   A. CR: Chlorosulfonated polyethylene synthetic rubber.
   B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.3 SUBMITTALS
   A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated; include performance curves.
   B. Certification Letter: For each type signed by product manufacturer.
   C. Shop Drawings: Schedule indicating manufacturer's number, scale range, and location for each.

1.5 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For meters and gages to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Palmer - Wahl Instruments, Inc.
      2. Trerice, H. O. Co.
      3. Weiss Instruments, Inc.
      4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
   B. Case: Die-cast aluminum or brass, 9 inches long.
   C. Tube: Blue reading, organic-liquid filled, with magnifying lens. Mercury filled thermometers will not be accepted.
   D. Tube Background: Satin-faced, non-reflective aluminum with permanently etched scale markings.
2.2 BIMETALLIC-ACTUATED DIAL THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Marsh Bellofram.
   3. Miljoco Corp.
   4. Trerice, H. O. Co.
   5. Weiss Instruments, Inc.
   6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3.

C. Case: Liquid-filled type, stainless steel with 5-inch (127-mm) diameter.

D. Element: Bimetal coil.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red or other dark-color metal.

G. Window: Glass.

H. Ring: Stainless steel.

I. Connector: Adjustable angle type.

J. Stem: Metal, for thermowell installation and of length to suit installation.

K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.3 THERMOWELLS

A. Manufacturers: Same as manufacturer of thermometer being used.

B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.4 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Ernst Flow Industries.
   3. Marsh Bellofram.
   4. Miljoco Corp.
5. Noshok, Inc.
6. Palmer - Wahl Instruments, Inc.
7. Trerice, H. O. Co.
8. Weiss Instruments, Inc.
9. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
10. WIKA Instrument Corporation.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.

1. Case:
   a. For steam and hydronic piping: Dry-type, drawn steel or cast aluminum, 4-1/2-inch (114-mm) diameter.
   b. For all other applications: Liquid-filled type, drawn steel or cast aluminum, 4-1/2-inch (114-mm) diameter.

2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.

3. Pressure Connection: Brass, NPS 1/4 (DN 8), bottom-outlet type unless back-outlet type is indicated.

4. Movement: Mechanical, with link to pressure element and connection to pointer.


6. Pointer: Red or other dark-color metal.

7. Window: Glass.

8. Ring: Metal.

9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.

10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure (100 kPa of vacuum to 103 kPa of pressure).

11. Range for Fluids under Pressure: Two times operating pressure.

C. Pressure-Gage Fittings:

1. Valves: NPS 1/4 (DN 8) brass or stainless-steel needle type.

2. Syphons: NPS 1/4 (DN 8) coil of brass tubing with threaded ends.

3. Snubbers: ASME B40.5, NPS 1/4 (DN 8) brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.5 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Flow Design, Inc.

2. MG Piping Products Co.


4. Peterson Equipment Co., Inc.

5. Sisco Manufacturing Co.

6. Trerice, H. O. Co.


B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).
D. Core Inserts: One or two self-sealing rubber valves.
   1. Insert material for air, water, or oil service at 20 to 200 deg F (minus 7 to plus 93 deg C) shall be CR.
   2. Insert material for air or water service at minus 30 to plus 275 deg F (minus 35 to plus 136 deg C) shall be EPDM.

2.6 WAFFER-ORIFICE FLOWMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB, Inc.; ABB Instrumentation.
   2. Armstrong Pumps, Inc.
   4. Bell & Gossett; ITT Industries.
   5. Meriam Instruments Div.; Scott Fetzer Co.

B. Description: Differential-pressure-design orifice insert for installation between pipe flanges; with calibrated flow-measuring element, separate flowmeter, hoses or tubing, valves, fittings, and conversion chart compatible with flow-measuring element, flowmeter, and system fluid.

C. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.

D. Pressure Rating: 300 psig (2070 kPa).

E. Temperature Rating: 250 deg F (121 deg C).

F. Range: Flow range of flow-measuring element and flowmeter shall cover operating range of equipment or system served.

G. Permanent Indicators: Suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- (150-mm-) diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.
   1. Scale: Gallons per minute (Liters per second).
   2. Accuracy: Plus or minus 1 percent of flow rate between 20 and 80 percent of range.

H. Portable Indicators: Differential-pressure type calibrated for connected flowmeter element and having two 12-foot (3.7-m) hoses in carrying case.
   1. Scale: Gallons per minute (Liters per second).
   2. Accuracy: Plus or minus 2 percent of flow rate between 20 and 80 percent of range.

I. Operating Instructions: Include complete instructions with each flowmeter.

2.7 VENTURI FLOWMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Armstrong Pumps, Inc.
   3. Hyspan Precision Products, Inc.
   5. McCrometer, Inc.
B. Description: Differential-pressure design for installation in piping; with calibrated flow-measuring element, separate flowmeter, hoses or tubing, valves, fittings, and conversion chart compatible with flow-measuring element, flowmeter, and system fluid.

C. Construction: Bronze, brass, or factory-primed steel; with brass fittings and attached tag with flow conversion data.

D. Pressure Rating: 250 psig (1725 kPa).

E. Temperature Rating: 250 deg F (121 deg C).

F. End Connections for NPS 2 (DN 50) and Smaller: Threaded.

G. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged or welded.

H. Range: Flow range of flow-measuring element and flowmeter shall cover operating range of equipment or system served.

I. Permanent Indicators: Suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- (150-mm-) diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.

1. Scale: Gallons per minute (Liters per second).
2. Accuracy: Plus or minus 1 percent of flow rate between 20 and 80 percent of range.

J. Portable Indicators: Differential-pressure type calibrated for connected flowmeter element and having two 12-foot (3.7-m) hoses in carrying case.

1. Scale: Gallons per minute (Liters per second).
2. Accuracy: Plus or minus 2 percent of flow rate between 20 and 80 percent of range.

K. Operating Instructions: Include complete instructions with each flowmeter.

2.8 ELECTROMAGNETIC FLOW METER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Onicon Inc.
2. Emerson Rosemount
3. Yokogawa.
4. Badger

B. Provide an Electromagnetic Flow Meter complete with integral electronics module. The flow meter shall be either a full bore flanged meter or insertion style meter installed in either the supply or return pipe of the system to be measured following the manufacturer’s installation instructions. Full bore style flow meters shall be installed via flanges matching the ANSI class 150 required for the application. The installing contractor is responsible for providing suitable mating flanges. For installations in non-metallic pipe, install grounding rings between flanges. Insertion style flow meters shall be installed through a 1” full port ball valve to enable insertion and removal of the meter without system shutdown. Insertion flow meters shall be hand-insertable up to 400 psi.

C. The manufacturer shall provide a certificate of NIST traceable wet-calibration for each flow meter. Accuracy shall be as follows: ± 0.4% of reading over a 10:1 turndown (from 3 to 30 ft./s).

D. Overall rangeability shall be from 1.3 ft./s to 33 ft./s (25:1 turndown ratio).
2.9 TURBINE FLOWMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Data Industrial Corp.
   2. Fischer, George, Inc.
   3. ONICON Incorporated.

B. Description: Insertion type for inserting turbine into piping and measuring flow directly in gallons per minute (liters per second).

C. Construction: Bronze or stainless-steel body; with plastic turbine or impeller and integral direct-reading scale.

D. Pressure Rating: 150 psig (1035 kPa) minimum.

E. Temperature Rating: 180 deg F (82 deg C) minimum.

F. Display: Visual instantaneous rate of flow, with register to indicate total volume in gallons (liters).

G. Accuracy: Plus or minus 2-1/2 percent of flow rate.

2.10 INSERTION-TURBINE, THERMAL-ENERGY METER SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Data Industrial Corp.
   2. ONICON Incorporated.
   3. Thermo Measurement Ltd.

B. Description: Flow sensor, strainer, two temperature sensors, transmitter, meter, and connecting wiring.

C. Flow Sensor: Insertion-type turbine or paddle-wheel element with corrosion-resistant-metal body and transmitter.
   2. Temperature Range: 40 to 250 deg F (5 to 121 deg C).
   3. Accuracy: Plus or minus 1 percent of flow rate.
D. Temperature Sensors: Solid state.
   1. Accuracy: Plus or minus 0.25 deg F of differential temperature.

E. Meter: Solid-state integrating type with integral battery pack.
   1. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units (joules).
   2. Battery Pack: Five-year lithium battery.

F. Strainer: Full size of main line piping.

2.11 INLINE-TURBINE, THERMAL-ENERGY METER SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Hoffer Flow Controls, Inc.
   3. ISTEC Corporation.
   4. Thermo Measurement Ltd.
   5. Venture Measurement.

B. Description: Flow sensor, strainer, two temperature sensors, transmitter, meter, and connecting wiring.

C. Flow Sensor: Turbine-type water meter with corrosion-resistant-metal body and transmitter.
   1. Pressure Rating: 150-psig (1035-kPa) minimum working-pressure rating.
   2. Temperature Range: 40 to 250 deg F (5 to 121 deg C).
   3. Accuracy: Plus or minus 1 percent of flow rate.

D. Temperature Sensors: Solid state.
   1. Accuracy: Plus or minus 0.25 deg F of differential temperature.

E. Meter: Solid-state integrating type with integral battery pack.
   1. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units (joules).
   2. Battery Pack: Five-year lithium battery.

F. Strainer: Full size of main line piping.

2.12 ULTRASONIC, THERMAL-ENERGY METER SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Controlotron Corporation.

B. Description: Flow sensor, two temperature sensors, transmitter, meter, and connecting wiring.

C. Flow Sensor: Strap-on or integral ultrasonic type with transmitter.
   1. Accuracy: Plus or minus 1 percent of flow rate.

D. Temperature Sensors: Solid state.
1. **Accuracy:** Plus or minus 0.25 deg F of differential temperature.

**E. Meter:** Solid-state integrating type with integral battery pack.

1. **Data Output:** Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units (joules).
2. **Battery Pack:** Five-year lithium battery.

**F. Strainer:** Full size of main line piping.

### PART 3 - EXECUTION

#### 3.1 THERMOMETER APPLICATIONS

**A.** Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler and chiller.
3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
4. Inlet and outlet of each hydronic heat exchanger.
5. Inlet and outlet of each hydronic heat-recovery unit.
6. Inlet and outlet of each thermal storage tank.
7. Outside-air, return-air, and mixed-air ducts.
8. Where indicated on the Drawings.

**B.** Provide the following temperature ranges for thermometers:

1. **Heating Hot Water:** 30 to 240 deg F, with 2-degree scale divisions (Minus 1 to plus 115 deg C, with 1-degree scale divisions).
2. **Condenser Water:** 0 to 160 deg F, with 2-degree scale divisions (Minus 18 to plus 71 deg C, with 1-degree scale divisions).
3. **Chilled Water:** 0 to 100 deg F, with 2-degree scale divisions (Minus 18 to plus 38 deg C, with 1-degree scale divisions).
4. **Steam and Condensate:** 30 to 300 deg F, with 5-degree scale divisions (Minus 1 to plus 150 deg C, with 2-degree scale divisions).
5. **Air Ducts:** 30 to 240 deg F, with 2-degree scale divisions (Minus 1 to plus 115 deg C, with 1-degree scale divisions).

#### 3.2 GAGE APPLICATIONS

**A.** Install pressure gages for discharge of each pressure-reducing valve.

**B.** Install pressure gages at chilled and condenser water inlets and outlets of chillers.

**C.** Install pressure gages at suction and discharge of each pump.

**D.** Install pressure gages where indicated on Drawings.

#### 3.3 INSTALLATIONS

**A.** Install thermometers and adjust vertical and tilted positions.

**B.** Install thermwells with socket extending to center of pipe and in vertical position in piping tees where thermometers are indicated.

**C.** **Duct Thermometer Support Flanges:** Install in wall of duct where duct thermometers are indicated. Attach to duct with screws.
D. Fill thermowells with heat conducting compounds.
E. Install pressure gages in piping tees with pressure gage located on pipe at most readable position.
F. Install needle-valve and snubber fitting in piping for each pressure gage for fluids (except steam).
G. Install needle-valve and syphon fitting in piping for each pressure gage for steam.
H. Install test plugs in tees in piping.
I. Install flow indicators, in accessible positions for easy viewing, in piping systems.
J. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters as prescribed by manufacturer's written instructions.
K. Install flowmeter elements in accessible positions in piping systems.
L. Install differential-pressure-type flowmeter elements with at least minimum straight lengths of pipe upstream and downstream from element as prescribed by manufacturer's written instructions.
M. Install wafer-orifice flowmeter elements between pipe flanges.
N. Install permanent indicators on walls or brackets in accessible and readable positions.
O. Install connection fittings for attachment to portable indicators in accessible locations.
P. Install flowmeters where indicated on the drawings.
Q. Comply with manufacturer's requirements for straight pipe upstream and downstream of flow meter.
R. Assemble components and install thermal-energy meters.
S. Mount meters on wall if accessible; if not, provide brackets to support meters.

3.4 CONNECTIONS
A. Install meters and gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines, and equipment.
B. Connect flowmeter-system elements to meters.
C. Connect flowmeter transmitters to meters.
D. Connect thermal-energy-meter transmitters to meters.

3.5 ADJUSTING
A. Calibrate meters according to manufacturer's written instructions, after installation.
B. Adjust faces of meters and gages to proper angle for best visibility.

END OF SECTION 230519
SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze angle valves.
2. Brass ball valves.
3. Bronze ball valves.
4. Iron ball valves.
5. Iron, single-flange butterfly valves.
7. Bronze lift check valves.
8. Bronze swing check valves.
10. Iron swing check valves with closure control.
12. Iron, plate-type check valves.
15. Bronze globe valves.
17. Lubricated plug valves.
18. Eccentric plug valves.

1.2 DEFINITIONS

A. CWP: Cold working pressure.
B. EPDM: Ethylene propylene copolymer rubber.
C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
D. NRS: Nonrising stem.
E. OS&Y: Outside screw and yoke.
F. RS: Rising stem.
G. SWP: Steam working pressure.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve indicated.

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
B. ASME Compliance:
   1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   2. ASME B31.1 for power piping valves.
   3. ASME B31.9 for building services piping valves.

1.6 DELIVERY, STORAGE, AND HANDLING
A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, and weld ends.
   3. Set angle, gate, and globe valves closed to prevent rattling.
   4. Set ball and plug valves open to minimize exposure of functional surfaces.
   5. Set butterfly valves closed or slightly open.
   6. Block check valves in either closed or open position.

B. Use the following precautions during storage:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES
A. Refer to HVAC valve schedule articles for applications of valves.
B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
C. Valve Sizes: Same as upstream piping unless otherwise indicated.
D. Valve Actuator Types:
   1. Gear Actuator: For quarter-turn valves NPS 8 (DN 200) and larger.
   2. Handwheel: For valves other than quarter-turn types.
   3. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller.
   4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.
E. Valves in Insulated, cold service and steam piping: With 2-inch (50-mm) stem extensions and the following features:
   1. Gate Valves: With rising stem.
   2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
F. Valve-End Connections:
   1. Flanged: With flanges according to ASME B16.1 for iron valves.
   2. Solder Joint: With sockets according to ASME B16.18.
   3. Threaded: With threads according to ASME B1.20.1.
G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE ANGLE VALVES

A. Class 125, Bronze Angle Valves with Stainless Steel Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo
   b. Bray
   c. Conbraco
   d. Crane Co.
   e. DeZurik
   f. Hammond Valve.
   g. Milwaukee Valve Company
   h. Nibco
   i. Watts.

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig (1380 kPa).
   d. Ends: Threaded or pressure-sealed.
   e. Stem and Disc: Stainless Steel.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 150, Bronze Angle Valves with Stainless Steel Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bray
   b. Crane Co.; Crane Valve Group; Stockham Division.
   c. Conbraco
   d. DeZurik
   e. Kitz Corporation
   f. Milwaukee Valve Company
   g. Watts.

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 300 psig (2070 kPa).
   d. Ends: Threaded.
   e. Stem and Disc: Stainless Steel.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron, bronze, or aluminum.

C. Class 150, Bronze Angle Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo
b. Bray

c. Crane Co.; Crane Valve Group; Stockham Division.

d. Conbraco

e. DeZurik

f. Hammond Valve.

g. Milwaukee Valve Company

h. NIBCO INC.

i. Powell Valves

j. Watts.

2. Description:

a. Standard: MSS SP-80, Type 2.

b. CWP Rating: 300 psig (2070 kPa).


d. Ends: Threaded.

e. Stem: Bronze.

f. Disc: PTFE.

g. Packing: Asbestos free.

h. Handwheel: Malleable iron, bronze, or aluminum.

2.3 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:


b. Milwaukee Valve Company.

c. NIBCO INC.

d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:


b. SWP Rating: 150 psig (1035 kPa).

c. CWP Rating: 600 psig (4140 kPa).

d. Body Design: Two piece.

e. Body Material: Bronze.

f. Ends: Threaded.

g. Seats: PTFE or TFE.

h. Stem: Stainless steel.

i. Ball: Stainless steel, vented.

j. Port: Full.

B. Three-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Bray

b. Crane

c. Conbraco Industries, Inc.; Apollo Valves.

d. DeZurik

e. Hammond Valve.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Watts.

2. Description:
   b. SWP Rating: 150 psig (1035 kPa).
   c. CWP Rating: 600 psig (4140 kPa).
   d. Body Design: Three piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Full.

2.4 IRON BALL VALVES
A. Class 125, Iron Ball Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Valve, Inc.
      b. Conbraco Industries, Inc.; Apollo Valves.
      c. Crane
      d. DeZurik
      e. Kennedy
      f. Kitz Corporation.
      g. Milwaukee
      h. Mueller
      i. Nibco
      j. Stockham
      k. Sure Flow Equipment Inc.
      l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

   2. Description:
      b. CWP Rating: 200 psig (1380 kPa).
      d. Body Material: ASTM A 126, gray iron.
      e. Ends: Flanged.
      f. Seats: PTFE or TFE.
      g. Stem: Stainless steel.
      h. Ball: Stainless steel.
      i. Port: Full.

2.5 IRON, SINGLE-FLANGE BUTTERFLY VALVES
A. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Bray Controls; a division of Bray International.
b. Conbraco Industries, Inc.; Apollo Valves.
c. Crane
d. DeZurik
e. Kennedy
f. Kitz
g. Milwaukee Valve Company.
h. Mueller
i. Nibco
j. Stockham
k. Tyco Valves & Controls; a unit of Tyco Flow Control.
l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 150 psig (1035 kPa).
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Aluminum bronze.

B. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bray Controls; a division of Bray International.
   b. Conbraco Industries, Inc.; Apollo Valves.
   c. Crane
d. DeZurik
e. Kennedy
f. Kitz
g. Milwaukee Valve Company.
h. Mueller Steam Specialty; a division of SPX Corporation.
i. NIBCO INC.
j. Stockham
k. Tyco Valves & Controls; a unit of Tyco Flow Control.
l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 150 psig (1035 kPa).
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Nickel-plated ductile iron.
C. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bray Controls; a division of Bray International.
   b. Conbraco Industries, Inc.; Apollo Valves.
   c. Crane
   d. DeZurik
   e. Kennedy
   f. Kitz
   g. Milwaukee Valve Company.
   h. Mueller Steam Specialty; a division of SPX Corporation.
   i. Nibco
   j. Stockham
   k. Tyco Valves & Controls; a unit of Tyco Flow Control.
   l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 150 psig (1035 kPa).
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Stainless steel.

D. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Crane
   c. DeZurik
   d. Kennedy
   e. Kitz
   f. Milwaukee Valve Company.
   g. Mueller
   h. Nibco
   i. Spence Strainers International; a division of CIRCOR International.
   j. Stockham
   k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Aluminum bronze.
E. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Crane
   c. DeZurik
   d. Kennedy
   e. Kitz
   f. Milwaukee Valve Company.
   g. Mueller Steam Specialty; a division of SPX Corporation.
   h. Nibco
   i. Stockham
   j. Spence Strainers International; a division of CIRCOR International.
   k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Nickel-plated or -coated ductile iron.

F. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Crane
   c. DeZurik
   d. Kennedy
   e. Kitz
   f. Milwaukee Valve Company.
   g. Mueller Steam Specialty; a division of SPX Corporation.
   h. NIBCO INC.
   i. Stockham
   j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Stainless steel.
2.6 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Class 150, Single-Flange, High-Performance Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bray Controls; a division of Bray International.
   b. Cooper Cameron Valves; a division of Cooper Cameron Corp.
   c. Crane
   d. DeZurik
   e. Flowseal
   f. Jamesbury; a subsidiary of Metso Automation.
   g. Kennedy
   h. Kitz
   i. Milwaukee Valve Company.
   j. Mueller
   k. Nibco
   l. Stockham
   m. Tyco Valves & Controls; a unit of Tyco Flow Control.

2. Description:
   a. Standard: MSS SP-68.
   b. CWP Rating: 285 psig (1965 kPa) at 100 deg F (38 deg C).
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: Carbon steel, cast iron, ductile iron, or stainless steel.
   e. Seat: Reinforced PTFE.
   f. Stem: Stainless steel; offset from seat plane.
   g. Disc: Carbon steel.
   h. Service: Bidirectional.

B. Class 300, Single-Flange, High-Performance Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bray Controls; a division of Bray International.
   b. Cooper Cameron Valves; a division of Cooper Cameron Corp.
   c. Crane
   d. DeZurik
   e. Flowseal
   f. Jamesbury; a subsidiary of Metso Automation.
   g. Kennedy
   h. Kitz
   i. Milwaukee Valve Company.
   j. Mueller
   k. Nibco
   l. Stockham
   m. Tyco Valves & Controls; a unit of Tyco Flow Control.

2. Description:
   a. Standard: MSS SP-68.
   b. CWP Rating: 720 psig (4965 kPa) at 100 deg F (38 deg C).
2.7 BRONZE SWING CHECK VALVES

A. Class 150, Bronze Swing Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bray
   b. Conbraco
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. DeZurik
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Watts

2. Description:
   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 300 psig (2070 kPa).
   c. Body Design: Horizontal flow.
   e. Ends: Threaded.
   f. Disc: Bronze.

B. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bray
   b. Crane
   c. Conbraco
   d. DeZurik
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-80, Type 4.
   b. CWP Rating: 300 psig (2070 kPa).
   c. Body Design: Horizontal flow.
   e. Ends: Threaded.
   f. Disc: PTFE or TFE.
2.8 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Stockham Division.
   b. DeZurik
   c. Kennedy
   d. Kitz
   e. Milwaukee Valve Company.
   f. Mueller
   g. NIBCO INC.
   h. Stockham
   i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Bronze.
   h. Gasket: Asbestos free.

B. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bray
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. DeZurik
   d. Kennedy
   e. Kitz
   f. Milwaukee
   g. Mueller
   h. Nibco
   i. Crane Co.; Crane Valve Group; Stockham Division.

2. Description:
   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Composition.
   h. Seat Ring: Bronze.
   i. Disc Holder: Bronze.
   j. Disc: PTFE or TFE.
   k. Gasket: Asbestos free.
C. Class 250, Iron Swing Check Valves with Metal Seats:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Co.; Crane Valve Group; Stockham Division.
      b. DeZurik
      c. Kennedy
      d. Kitz
      e. Milwaukee Valve Company.
      f. Mueller
      g. NIBCO INC.
      h. Stockham
      i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

   2. Description:
      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
      c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
      d. Body Design: Clear or full waterway.
      e. Body Material: ASTM A 126, gray iron with bolted bonnet.
      f. Ends: Flanged.
      g. Trim: Stainless Steel.
      h. Gasket: Asbestos free.

2.9 IRON SWING CHECK VALVES WITH CLOSURE CONTROL
A. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane
      b. DeZurik
      c. Kennedy
      d. Kitz
      e. Milwaukee
      f. Mueller
      g. NIBCO INC.
      h. Stockham

   2. Description:
      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      d. Body Design: Clear or full waterway.
      e. Body Material: ASTM A 126, gray iron with bolted bonnet.
      f. Ends: Flanged.
      g. Trim: Stainless Steel.
      h. Gasket: Asbestos free.
      i. Closure Control: Factory-installed, exterior lever and spring.
B. Class 125, Iron Swing Check Valves with Lever and Weight-Closure Control:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Co.; Crane Valve Group; Stockham Division.
      b. DeZurik
      c. Hammond Valve.
      d. Kennedy
      e. Kitz
      f. Milwaukee Valve Company.
      g. Mueller
      h. NIBCO INC.
      i. Stockham
      j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   2. Description:
      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      d. Body Design: Clear or full waterway.
      e. Body Material: ASTM A 126, gray iron with bolted bonnet.
      f. Ends: Flanged.
      g. Trim: Bronze.
      h. Gasket: Asbestos free.
      i. Closure Control: Factory-installed, exterior lever and weight.

2.10 IRON, CENTER-GUIDED CHECK VALVES

A. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane
      b. DeZurik
      c. Kennedy
      d. Kitz
      e. Milwaukee Valve Company.
      f. Mueller
      g. NIBCO INC.
      h. Stockham
      i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   2. Description:
      b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      d. Body Material: ASTM A 126, gray iron.
      e. Style: Compact wafer.
      f. Seat: Bronze.
B. Class 125, Iron, Globe, Center-Guided Check Valves with Metal Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane
      b. DeZurik
      c. Kennedy
      d. Kitz
      e. Milwaukee Valve Company.
      f. Mueller
      g. NIBCO INC.
      h. Stockham
      i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   2. Description:
      b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      d. Body Material: ASTM A 126, gray iron.
      e. Style: Globe, spring loaded.
      f. Ends: Flanged.
      g. Seat: Bronze.

C. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. APCO Willamette Valve and Primer Corporation.
      b. Crane
      c. Crispin Valve.
      d. Crane
      e. DeZurik
      f. Kennedy
      g. Kitz
      h. Milwaukee Valve Company.
      i. Mueller
      j. NIBCO INC.
      k. Stockham
      l. Val-Matic Valve & Manufacturing Corp.
   2. Description:
      b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
      c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
      e. Style: Compact wafer.
      f. Seat: Bronze.

D. Class 150, Iron, Globe, Center-Guided Check Valves with Metal Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. APCO Willamette Valve and Primer Corporation.
b. Crane
c. Crispin Valve.
d. Crane
e. DeZurik
f. Kennedy
g. Kitz
h. Milwaukee Valve Company.
i. Mueller
j. NIBCO INC.
k. Stockham
l. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
   e. Style: Globe, spring loaded.
   f. Ends: Flanged.
   g. Seat: Bronze.

E. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane
      b. DeZurik
c. Kennedy
d. Kitz
e. Milwaukee Valve Company.
f. Mueller
g. NIBCO INC.
h. Stockham

2. Description:
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
   d. Body Material: ASTM A 126, gray iron.
   e. Style: Compact wafer, spring loaded.
   f. Seat: Bronze.

F. Class 250, Iron, Globe, Center-Guided Check Valves with Metal Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane
      b. DeZurik
c. Kennedy
d. Kitz
e. Milwaukee Valve Company.
2. Description:
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
   d. Body Material: ASTM A 126, gray iron.
   e. Style: Globe, spring loaded.
   f. Ends: Flanged.
   g. Seat: Bronze.

G. Class 300, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crane
   c. Crispin Valve.
   d. Crane
   e. DeZurik
   f. Kennedy
   g. Kitz
   h. Milwaukee Valve Company.
   i. Mueller
   j. NIBCO INC.
   k. Stockham
   l. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 400 psig (2760 kPa).
   e. Style: Compact wafer, spring loaded.
   f. Seat: Bronze.

H. Class 300, Iron, Globe, Center-Guided Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crane
   c. Crispin Valve.
   d. Crane
   e. DeZurik
   f. Kennedy
   g. Kitz
   h. Milwaukee Valve Company.
   i. Mueller
   j. NIBCO INC.
2. Description:
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 400 psig (2760 kPa).
   e. Style: Globe, spring loaded.
   f. Ends: Flanged.
   g. Seat: Bronze.

I. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane
      b. DeZurik
      c. Kennedy
      d. Kitz
      e. Milwaukee Valve Company.
      f. Mueller
      g. NIBCO INC.
      h. Stockham

2. Description:
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
   d. Body Material: ASTM A 126, gray iron.
   e. Style: Compact wafer.
   f. Seat: EPDM.

J. Class 125, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane
      b. DeZurik
      c. Kennedy
      d. Kitz
      e. Milwaukee Valve Company.
      f. Mueller
      g. NIBCO INC.
      h. Stockham

2. Description:
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
   d. Body Material: ASTM A 126, gray iron.
   e. Style: Globe, spring loaded.
f. Ends: Flanged.
g. Seat: EPDM.

K. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crane
   c. Crispin Valve.
   d. DeZurik
   e. Kennedy
   f. Kitz
   g. Milwaukee Valve Company.
   h. Mueller
   i. NIBCO INC.
   j. Stockham
   k. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
   e. Style: Compact wafer.
   f. Seat: EPDM.

L. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane
   b. DeZurik
   c. Kennedy
   d. Kitz
   e. Milwaukee Valve Company.
   f. Mueller
   g. NIBCO INC.
   h. Stockham

2. Description:
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
   d. Body Material: ASTM A 126, gray iron.
   e. Style: Compact wafer, spring loaded.
   f. Seat: EPDM.

M. Class 250, Iron, Globe, Center-Guided Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane
2. Description:
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
   d. Body Material: ASTM A 126, gray iron.
   e. Style: Globe, spring loaded.
   f. Ends: Flanged.
   g. Seat: EPDM.

2.11 BRONZE GATE VALVES

A. Class 150, NRS Bronze Gate Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Bray
      b. Crane
      c. Conbraco
      d. DeZurik
      e. Milwaukee Valve Company.
      f. NIBCO INC.
      g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

   2. Description:
      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 300 psig (2070 kPa).
      d. Ends: Threaded.
      e. Stem: Bronze.
      f. Disc: Solid wedge; bronze.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron.

B. Class 150, RS Bronze Gate Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Bray
      b. Crane
      c. Conbraco
      d. DeZurik
      e. Milwaukee Valve Company.
      f. NIBCO INC.
      g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig (2070 kPa).
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

2.12 IRON GATE VALVES
A. Class 125, NRS, Iron Gate Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane
      b. DeZurik
      c. Kennedy
      d. Kitz
      e. Milwaukee Valve Company.
      f. Mueller
      g. NIBCO INC.
      h. Stockham
      i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

   2. Description:
      a. Standard: MSS SP-70, Type I.
      b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      d. Body Material: ASTM A 126, gray iron with bolted bonnet.
      e. Ends: Flanged.
      f. Trim: Bronze.
      g. Disc: Solid wedge.
      h. Packing and Gasket: Asbestos free.

B. Class 125, OS&Y, Iron Gate Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane
      b. DeZurik
      c. Kennedy
      d. Kitz
      e. Milwaukee Valve Company.
      f. Mueller
      g. NIBCO INC.
      h. Stockham
      i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

   2. Description:
      a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

2.13 BRONZE GLOBE VALVES

A. Class 150, Bronze Globe Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bray
   b. Crane
   c. Conbraco
   d. DeZurik
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig (2070 kPa).
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

2.14 IRON GLOBE VALVES

A. Class 125, Iron Globe Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane
   b. DeZurik
   c. Kennedy
   d. Kitz
   e. Milwaukee Valve Company.
   f. Mueller
   g. NIBCO INC.
   h. Stockham
   i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-85, Type I.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Material: ASTM A 126, gray iron with bolted bonnet.
B. Class 250, Iron Globe Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Milwaukee Valve Company.
      b. NIBCO INC.
      c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   2. Description:
      a. Standard: MSS SP-85, Type I.
      b. CWP Rating: 500 psig (3450 kPa).
      c. Body Material: ASTM A 126, gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Stainless Steel.
      f. Packing and Gasket: Asbestos free.

2.15 CHAINWHEELS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Babbitt Steam Specialty Co.
   2. Roto Hammer Industries.
   3. Trumbull Industries.
B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
   1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
   2. Attachment: For connection to ball and butterfly valve stems.
   3. Sprocket Rim with Chain Guides: Ductile or cast iron, of type and size required for valve.
   4. Chain: Stainless steel, of size required to fit sprocket rim.

PART 3 - EXECUTION
3.1 EXAMINATION
A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
C. Examine threads on valve and mating pipe for form and cleanliness.
D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
E. Do not attempt to repair defective valves; replace with new valves.
3.2 VALVE INSTALLATION
A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
B. Locate valves for easy access and provide separate support where necessary.
C. Install valves in horizontal piping with stem at or above center of pipe.
D. Install valves in position to allow full stem movement.
E. Install chainwheels on operators for ball, butterfly, gate and globe valves NPS 3 (DN 75) and larger and more than 84 inches above floor. Extend chains to 60 inches above finished floor.
F. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
   3. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING
A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS
A. If valve applications are not indicated, use the following:
   1. Shutoff Service: Ball, butterfly, or gate valves.
   2. Shutoff Service at Source Equipment: High-performance butterfly valves
   4. Throttling Service except Steam: Globe valves.
   5. Throttling Service, Steam: Globe valves.
   6. Pump-Discharge Check Valves:
      a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with nonmetallic disc.
      b. NPS 2-1/2 (DN 65) and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal or resilient-seat check valves.
B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.
C. Select valves, except wafer types, with the following end connections:
   1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint or pressure-seal valve-end option is indicated in valve schedules below.
   2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged or pressure-sealed ends.
   3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
   4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
   5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends.
   6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

3.5 CHILLED-WATER VALVE SCHEDULE
A. Pipe NPS 2 (DN 50) and Smaller:
1. Bronze Valves: May be provided with solder-joint or pressure-seal ends instead of threaded ends.
2. Ball Valves: Two piece, full port, bronze with stainless-steel trim.
3. Bronze Swing Check Valves: Class 150, bronze or nonmetallic disc.
4. Bronze Globe Valves: Class 150, bronze or nonmetallic disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
4. High-Performance Butterfly Valves: Class 150, single flange.
5. Iron Swing Check Valves: Class 250, nonmetallic-to-metal seats.
6. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and weight.
7. Iron, Center-Guided Check Valves: Class 150, compact-wafer or globe resilient seat.
8. Iron Gate Valves: Class 250, OS&Y.

3.6 CONDENSER-WATER VALVE SCHEDULE
A. Pipe NPS 2 (DN 50) and Smaller:
1. Bronze Valves: May be provided with solder-joint or pressure-seal ends instead of threaded ends.
2. Ball Valves: Two piece, full port, bronze with stainless-steel trim.
3. Bronze Swing Check Valves: Class 150, nonmetallic disc.
4. Bronze Gate Valves: Class 150, NRS.
5. Bronze Globe Valves: Class 150, nonmetallic disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
4. High-Performance Butterfly Valves: Class 150, single flange.
5. Iron Swing Check Valves: Class 250, nonmetallic-to-metal seats.
6. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and weight.
7. Iron, Center-Guided Check Valves: Class 150, compact-wafer or globe resilient seat.
8. Iron Gate Valves: Class 250, OS&Y.

3.7 HEATING-WATER VALVE SCHEDULE
A. Pipe NPS 2 (DN 50) and Smaller:
1. Bronze Valves: May be provided with solder-joint or pressure-seal ends instead of threaded ends.
2. Ball Valves: Two piece, full port, bronze with stainless-steel trim.
3. Bronze Swing Check Valves: Class 150, nonmetallic disc.
4. Bronze Gate Valves: Class 150, NRS.
5. Bronze Globe Valves: Class 150, nonmetallic disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
4. High-Performance Butterfly Valves: Class 150, single flange.
5. Iron Swing Check Valves: Class 250, nonmetallic-to-metal seats.
6. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and weight.
7. Iron, Center-Guided Check Valves: Class 150, compact-wafer or globe resilient seat.
8. Iron Gate Valves: Class 250, OS&Y.

3.8 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG (104 KPA) OR LESS)
A. Pipe NPS 2 (DN 50) and Smaller:
1. Ball Valves: Two piece, full port, bronze with stainless-steel trim.
2. Bronze Swing Check Valves: Class 150, bronze disc.
3. Bronze Gate Valves: Class 150, NRS.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
2. High-Performance Butterfly Valves: Class 150, single flange.
3. Iron Swing Check Valves: Class 250, metal seats.
4. Iron Gate Valves: Class 250, OS&Y.
5. Iron Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 250.

3.9 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG (104 KPA))
A. Pipe NPS 2 (DN 50) and Smaller:
1. Ball Valves: Two piece, full port, bronze with stainless-steel trim.
2. Bronze Swing Check Valves: Class 150, bronze disc.
3. Bronze Gate Valves: Class 150, NRS, bronze.

B. Pipe Sizes NPS 2-1/2 (DN 65) and Larger:
1. Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150, iron.
2. High-Performance Butterfly Valves: Class 150, single flange.
3. Iron Swing Check Valves: Class 250, metal seats.
4. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and weight.
5. Iron Gate Valves: Class 250, OS&Y.
3.10 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:
   1. Ball Valves: Two piece, full port, bronze with stainless-steel trim.
   2. Bronze Swing Check Valves: Class 150, bronze disc.
   3. Bronze Gate Valves: Class 150, NRS.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
   1. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
   2. High-Performance Butterfly Valves: Class 150, single flange.
   3. Iron Swing Check Valves: Class 250, metal seats.
   4. Iron Gate Valves: Class 250, OS&Y.
   5. Iron Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 250.
SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes hangers and supports for HVAC system piping and equipment:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Pipe stands.
   6. Equipment supports.

1.2 DEFINITIONS
A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry, Inc.
B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.3 PERFORMANCE REQUIREMENTS
A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.4 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.5 ACTION SUBMITTALS
A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Thermal-hanger shield inserts.
B. Shop Drawings: Assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly of components.
   1. Trapeze pipe hangers. Include Product Data for components.
   2. Metal framing systems. Include Product Data for components.
   3. Pipe stands. Include Product Data for components.
   4. Equipment supports.

1.6 INFORMATIONAL SUBMITTALS
A. Qualification Data
   1. Installer Qualifications.
   2. Welding Certificates.
1.7 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to the following:
   1. AWS D1.1, "Structural Welding Code-Steel."
   4. AWS D1.4, "Structural Welding Code-Reinforcing Steel."
   5. ASME Boiler and Pressure Vessel Code: Section IX.

1.8 BUILDING ATTACHMENTS

A. Steel Frame Structures: In general, attach all mechanical work to building steel. Install intermediate support steel between building steel if support between beams or joists is required.
   1. Mechanical work shall not be hung from metal roof deck.
   2. Where composite floor slab is present, drilled-in-wedge-type expansion anchors may be used in locations approved by Architect. If use of expansion anchors is proposed, submit for approval by Architect locations, load and attachment details. All anchor materials to be used shall be as specified in specification sections pertaining to building structure and as approved by the Architect (powder actuated inserts shall not be used).

B. Concrete Frame Structures: In general, attach all mechanical work to building structure utilizing either cast-in-place inserts or drilled-in-wedge expansion anchors. Submit for approval by Architect, locations, loads and attachment details for all mechanical work. All anchor materials to be used shall be as specified in specification sections pertaining to building structure and as approved by the Architect (powder actuated inserts shall not be used).
   1. If cast-in-place inserts are proposed, provide building attachment submittal data with structural concrete reinforcement shop drawings.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Anvil
B. B-Line
C. Carpenter and Patterson
D. Fee and Mason
E. Michigan
F. Reliable and Viking

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.
B. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.
C. Nonmetallic Coatings: Plastic coating, jacket, or liner.
D. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.
2.3 TRAPEZE PIPE HANGERS
   A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS
   A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.
   B. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
   C. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS
   A. Description: 100-psig- (690-kPa-) minimum, compressive-strength insulation insert encased in sheet metal shield.
   B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with vapor barrier.
   C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate.
   D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
   E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
   F. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.6 PIPE STAND FABRICATION
   A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support floor or roof-mounted piping.

2.7 EQUIPMENT SUPPORTS
   A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.8 MISCELLANEOUS MATERIALS
   A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
   B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
      2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS
   A. Specific hanger and support requirements are specified in sections specifying piping systems and equipment.
B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F (49 to 232 deg C) pipes, NPS 4 to NPS 16 (DN 100 to DN 400), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24 (DN 20 to DN 600), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24 (DN 15 to DN 600), if little or no insulation is required.
5. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8 (DN 20 to DN 200).
6. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2 (DN 15 to DN 50).
7. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8 (DN 10 to DN 200).
8. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3 (DN 10 to DN 80).
9. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
10. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36 (DN 100 to DN 900), with steel pipe base stanchion support and cast-iron floor flange.
11. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36 (DN 100 to DN 900), with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
12. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36 (DN 65 to DN 900), if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
13. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30 (DN 25 to DN 750), from 2 rods if longitudinal movement caused by expansion and contraction might occur.
14. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20 (DN 65 to DN 500), from single rod if horizontal movement caused by expansion and contraction might occur.
15. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42 (DN 50 to DN 1050), if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
16. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24 (DN 50 to DN 600), if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
17. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30 (DN 50 to DN 750), if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500), if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

I. Building Attachments: Unless otherwise indicated for piping system, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb (340 kg).
   b. Medium (MSS Type 32): 1500 lb (680 kg).
   c. Heavy (MSS Type 33): 3000 lb (1360 kg).
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. **Horizontal Travelers (MSS Type 58):** For supporting piping systems subject to linear horizontal movement where headroom is limited.

J. **Saddles and Shields:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. **Steel Pipe-Covering Protection Saddles (MSS Type 39):** To fill interior voids with insulation that matches adjoining insulation.
2. **Protection Shields (MSS Type 40):** Of length recommended in writing by manufacturer to prevent crushing insulation.
3. **Thermal-Hanger Shield Inserts:** For supporting insulated pipe.

K. **Spring Hangers and Supports:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. **Spring Cushions (MSS Type 48):** For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
2. **Spring-Cushion Roll Hangers (MSS Type 49):** For equipping Type 41 roll hanger with springs.
3. **Variable-Spring Hangers (MSS Type 51):** Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
4. **Variable-Spring Base Supports (MSS Type 52):** Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
5. **Variable-Spring Trapeze Hangers (MSS Type 53):** Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
6. **Constant Supports:** For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
   a. **Horizontal (MSS Type 54):** Mounted horizontally.
   b. **Vertical (MSS Type 55):** Mounted vertically.
   c. **Trapeze (MSS Type 56):** Two vertical-type supports and one trapeze member.

L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

### 3.2 HANGER AND SUPPORT INSTALLATION

**A. Steel Pipe Hanger Installation:** Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

**B. Trapeze Pipe Hanger Installation:** Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.

1. **Pipes of Various Sizes:** Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
3. Secure individual pipes to trapeze pipe hanger with pipe clamps to prevent lateral piping movement.

C. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP 58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Hydronic, Steam and Condensate Heating Piping
1. Install hangers for steel piping with the following maximum spacing:
   a. NPS 3/4 (DN 20): Maximum span, 7 feet (2.1 m).
   b. NPS 1 (DN 25): Maximum span, 7 feet (2.1 m).
   c. NPS 1 1/2 (DN 40): Maximum span, 9 feet (2.7 m).
   d. NPS 2 (DN 50): Maximum span, 10 feet (3 m).
   e. NPS 2 1/2 (DN 65): Maximum span, 11 feet (3.4 m).
   f. NPS 3 (DN 80) and Larger: Maximum span, 12 feet (3.7 m).
2. Install hangers for drawn temper copper piping with the following maximum spacing and minimum rod sizes:
   a. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
   b. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
   c. NPS 1 1/4 (DN 32): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
   d. NPS 1 1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
   e. NPS 2 and Larger (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).

E. Refrigerant Piping
1. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
   a. NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
   b. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
   c. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod size, 1/4 inch (6.4 mm).
   d. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
e. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).

f. NPS 2 (DN 50): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).

g. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2700 mm); minimum rod size, 3/8 inch (9.5 mm).

h. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).

i. NPS 4 (DN 100): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (13 mm).

2. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

   a. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).

   b. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 3/8 inch (9.5 mm).

   c. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (9.5 mm).

   d. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod size, 1/2 inch (13 mm).

3. Support multi-floor vertical runs at least at each floor.

F. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

G. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

H. Pipe Stand Installation:
   1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

   2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.

I. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.


K. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

L. Install lateral bracing with pipe hangers and supports to prevent swaying.

M. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

O. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
b. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

3. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
   b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
   c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
   d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
   e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

4. Pipes NPS 8 (DN 200) and Larger: Include wood inserts.
5. Insert Material: Length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS
   A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
   B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
   C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS
   A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
   B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
   C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
      1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
      2. Obtain fusion without undercut or overlap.
      3. Remove welding flux immediately.
      4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING
   A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

C. Protect the ends of continuous-thread hangers and support rods with rubber or vinyl end caps. The caps shall be min.1/2-inch in length.

3.6 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 230529
SECTION 230533 - HEAT TRACING FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes heat tracing with the following electric heating cables:
      1. Self-regulating, parallel resistance.

1.2 SUBMITTALS
   A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS
   A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
      1. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.
   B. Shop Drawings: For electric heating cable.
      1. Layout Drawings: Include plans, sections, details, and attachments to other work.
      2. Wiring Diagrams: Power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS
   A. Field Quality Control Test Reports.

1.5 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.
      1. Special Warranty: Submit manufacturer’s standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1.6 QUALITY ASSURANCE
   A. The electric heat tracing system shall be manufactured, installed and tested in accordance with the applicable requirements of the latest edition of the following codes and standards.
      1. ANSI American National Standards Institute
      2. CEC Canadian Electrical Code
      3. CSA CSA International
      4. FM FM Approvals
      5. IEC International Electro-Mechanical Commission
      6. IEEE Institute of Electrical and Electronics Engineers
      7. ITS Intertek Testing Services (Intertek ETL SEMKO)
      8. NEC U.S. National Electrical Code (NFPA 70)
      9. NEMA National Electrical Manufacturers Association
     10. NESC National Electrical Safety Code
     11. UL Underwriters’ Laboratories, Inc.
B. Special Warranty: Submit manufacturer's standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.1 SELF-REGULATING PARALLEL RESISTANCE HEAT TRACING SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Raychem; a division of Tyco Thermal Controls.
2. Chromalox.
3. Thermon
4. Pentair

B. General: Provide self-regulating parallel resistance heat tracing system for applications with continuous exposure (maintained) temperatures from 150°F (65°C) to 250°F (121°C). The self-regulating heating cable shall vary its power output relative to the temperature of the surface of the pipe or the vessel. The cable shall be designed such that it can be crossed over itself and cut to length in the field. The self-regulating heating cable shall be designed for a useful life of 20 years or more with "power on" continuously, based on the following useful life criteria:

1. Retention of at least 75 percent of nominal rated power after 20 years of operation at the maximum published continuous exposure (maintain) temperature.
2. Retention of at least 90 percent of nominal rated power after 1000 hours of operation at the maximum published intermittent exposure temperature. The testing shall conform to UL 746B, IEC 216-1 Part 1.
3. Provide warranty against manufacturing defects for a period of 10 years after installation. All cables shall be capable of passing a 2.5 kV dielectric test for one minute (ASTM 2633) after undergoing a 0.5 kg-m impact (BS 6351, Part 1, 8.1.10).

C. Freeze-Protection Systems:

1. Provide heating cable consist of two 16 AWG or larger nickel-plated copper bus wires, embedded in a self-regulating polymeric core that controls power output so that the cable can be used directly on plastic or metallic pipes. Cables shall have a temperature identification number (T-rating) of T6 (185°F or 85°C) without use of thermostats.
2. Provide ground-fault protection device set at 30 mA, with a nominal 100-ms response time, to protect each circuit.
3. The heating cable shall have a tinned copper braid with a resistance less than the heating cable bus wire resistance as determined in type test (ASTM, B193, Sec. 5). The braid shall be protected from chemical attack and mechanical abuse by a modified polyolefin or fluoropolymer outer jacket.
4. All heat trace to have 5 W/ft output unless otherwise noted on drawings. Greater outputs require approval of Owner.
5. To provide rapid heat-up, to conserve energy, and to prevent overheating of fluids and plastic pipe, the heating cable shall have minimum self-regulating indices as tabulated below:

Minimum Self-Regulating Indices:

<table>
<thead>
<tr>
<th>Heating Cable</th>
<th>S.R. Index (W/Deg. F)</th>
<th>S.R. Index (W/Deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 W/ft</td>
<td>0.038</td>
<td>0.068</td>
</tr>
<tr>
<td>5 W/ft</td>
<td>0.060</td>
<td>0.108</td>
</tr>
<tr>
<td>8 W/ft</td>
<td>0.074</td>
<td>0.133</td>
</tr>
<tr>
<td>10 W/ft</td>
<td>0.100</td>
<td>0.180</td>
</tr>
</tbody>
</table>

The self-regulating index is the rate of change of power output in watts per degree Fahrenheit or watts per degree Celsius, as measured between the temperatures of 50°F (10°C) and 100°F (38°C) and confirmed by the type test and published data sheets.

6. To ensure that the self-regulating heating cable does not increase power output when accidentally exposed to high temperatures, resulting in thermal runaway and self-ignition, the cable shall produce less than 0.5 watts per foot (1.64 watts per meter) when energized and heated to 350°F (177°C) for 30 minutes.

7. The heating cable shall be equal to Raychem® BTV-CT or BTV-CR self-regulating heater, with continuous exposure (maintain) capability up to 150°F (65°C) and intermittent exposure capability up to 185°F (85°C), as manufactured by Tyco Thermal Controls.

D. Freeze Protection and Process Temperature Maintenance with Steam Exposure Systems:

1. Provide heating cable consisting of two 14 AWG nickel-plated copper bus wires, separated by a fluoropolymer spacer and helically wrapped with a self-regulating fluoropolymer fiber that controls power output so that the cable has an unconditional temperature identification number (T-rating) of T2C (446°F or 230°C) or lower without use of thermostats.

2. Provide a ground-fault protection device set at 30 mA, with a nominal 100-ms response time, shall be used to protect each circuit.

3. The heating cable shall have a tinned copper braid with a resistance less than the heating cable bus wire resistance as determined in type test (ASTM, B193, Sec. 5). The braid shall be protected from chemical attack and mechanical abuse by a modified polyolefin or fluoropolymer outer jacket.

4. All heat trace to have 5 W/ft output unless otherwise noted on drawings. Greater outputs require approval of Owner.

5. To provide rapid heat-up, to conserve energy, and to prevent overheating of fluids and plastic pipe, the heating cable shall have minimum self-regulating indices as tabulated below:

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</tr>
<tr>
<td>10 W/ft</td>
<td>0.100</td>
<td>0.180</td>
</tr>
</tbody>
</table>
The self-regulating index is the rate of change of power output in watts per degree Fahrenheit or watts per degree Celsius, as measured between the temperatures of 50°F (10°C) and 100°F (38°C) and confirmed by the type test and published data sheets.

6. The heating cable shall be Raychem XTV-CT self-regulating heater, for continuous exposure (maintain) capability up to 250°F (121°C) and intermittent exposure capability up to 420°F (215°C or 250 psi steam), as manufactured by Tyco Thermal Controls.

E. Systems for Division 1 Hazardous Locations: The following requirements shall apply in addition to the criteria specified above:

1. The self-regulating heating cable shall be specifically FM Approved or CSA Certified for use in Division 1 locations.
2. The temperature identification number (T-rating) of the cable used shall comply with FM and CSA requirements as applicable.
3. Connection methods used with the cable shall be compatible and approved as a part of the system manufactured and supplied by the heating cable vendor for use in the Division 1 location.
4. For plastic pipe and vessel applications, the heating cable shall be Raychem HBTV-CT or Raychem BTV-CT self-regulating heaters, with continuous exposure capability up to 150°F (65°C) and intermittent exposure capability up to 185°F (85°C), as manufactured by Tyco Thermal Controls.
5. The heating cable shall be Raychem HQTV-CT or Raychem QTVR-CT self-regulating heaters, for continuous and intermittent exposure capability up to 225°F (110°C), as manufactured by Tyco Thermal Controls.
6. The heating cable shall be equal to Raychem HXTV-CT or Raychem XTV-CT self-regulating heaters, for continuous exposure (maintain) capability up to 250°F (121°C) and intermittent exposure capability up to 420°F (215°C or 250 psi steam), as manufactured by Tyco Thermal Controls.

F. Terminations for Nonhazardous and Hazardous Class 1, Division 2 Locations: The following requirements shall apply in addition to the criteria specified above:

1. All connection components used to terminate heating cables, including power connectors, splices, tees, and connectors shall be approved for the respective area classification and approved as a system with the particular type of heating cable in use. Under no circumstances shall terminations be used which are manufactured by a vendor other than the cable manufacturer.
2. In order to keep connections dry and corrosion resistant, components shall be constructed of nonmetallic, electrostatic, charge-resistant, glass-filled, engineered polymer enclosure rated NEMA 4X. The component stand shall allow for up to four inches (100 mm) of thermal insulation.
3. Terminals shall be spring clamp wire connection type to provide reliable connection, maintenance-free operation, and ease of reentry.
4. Heating cable terminations shall use cold-applied materials and shall not require the use of a heat gun, torch, or hot work permit for installation.
5. Components shall be rated to a minimum installation temperature of −40°F (−40°C), minimum usage temperature of −75°F (−60°C), and maximum pipe temperature of 500°F (260°C).
6. The component system shall be equal to Raychem JBM-100-L-A connection kit complete with integral LED power indicating light to serve as complete power, splice, or tee connection for up to three Raychem BTV, QTVR, or XTV industrial parallel heating cables as manufactured by Tyco Thermal Controls.
G. Single- or Dual-Point Control and Monitoring Devices:
   1. The system shall be field-mounted and shall have FM or CSA approval for Class I, Division 2, Groups A, B, C, D when using a solid-state switching device.
   2. The system shall provide the user with the option of line-sensing control with a user selectable dead band, ambient sensing, proportional ambient sensing, and power limiting control modes.
   3. The system shall provide an isolated solid-state alarm relay or a dry contact relay for alarm annunciation back to a Distributed Control System (DCS).
   4. Electrical code-approved ground-fault detection equipment shall be integral to the controller to simplify installation and reduce total cost.
   5. Enclosure type shall be NEMA 4X fiberglass reinforced plastic (FRP) or stainless steel for corrosion resistance and protection from moisture.
   6. Monitor and control of heat tracing to be connected from the heat tracing control panel into the Building Automation System (BACNET).
      a. Loss of power (alarm).
      b. Failure to activate (alarm).
      c. Heat trace on/off (monitor).
      d. Fluid temperature through immersion temperature probe (alarm if fluid drops 5 deg. F below heat trace temperature after initial heat-up).

H. Thermostats and Contactors:
   1. Freeze protection systems shall operate using self-regulating control or with the DigiTrace AMC-1A or DigiTrace AMC-F5 thermostat and the DigiTrace E104-100A or DigiTrace E304-40A contactor in nonhazardous locations, and DigiTrace AMC-1H thermostat with DigiTrace E307-40A contactor in hazardous locations as supplied by Tyco Thermal Controls.
   2. Process temperature maintenance systems shall operate using self-regulating control or with DigiTrace AMC-1B thermostat and DigiTrace E104-100A or DigiTrace E304-40A contactor in non hazardous locations and DigiTrace E507S-LS or DigiTrace RAYSTAT-EX-03-A thermostats and DigiTrace E307-40A contactor in hazardous locations, as supplied by Tyco Thermal Controls.

I. Capacities and Characteristics:
   1. Scope of heat tracing work is indicated on the Drawings.
   2. Provide a detailed design based on scope and parameters indicated on the drawings utilizing standard heat-tracing design software, such as Tyco Thermal Controls TraceCalc® Pro design software or equal. At minimum, the design must provide the following:
      a. Circuit identification number.
      b. Maintained temperature.
      c. Line size and insulation.
      d. Heat loss for pipe, valves and supports.
      e. Amount and type of heating cable required.
      f. Spiral requirements.
      g. Heating cable service voltage.
      h. Heating cable power output at the maintained temperature.
      i. Minimum and maximum maintain temperature vs. minimum and maximum ambient temperatures.
      j. Circuit breaker and transformer sizing.
3. Unless otherwise noted on the drawings, select heat trace cable output to maintain fluid temperature at 45 degree F with -10 degree F ambient air temperature, 20 mph wind speed and R=8 pipe insulation.

2.2 ACCESSORIES
A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.
B. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils (0.08 mm) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
   1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.
   2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.
   1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
   2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. Install electric heating cable across expansion joints according to manufacturer's written recommendations using slack cable to allow movement without damage to cable.
B. Install electric heating cables after piping has been tested and before insulation is installed.
C. Install electric heating cables according to IEEE 515.1.
D. Install insulation over piping with electric cables according to Division 23 Section "HVAC Insulation."
E. Install warning tape on piping insulation where piping is equipped with electric heating cables.
F. Set field-adjustable switches and circuit-breaker trip ranges.
G. Protect installed heating cables, including nonheating leads, from damage.

3.3 CONNECTIONS
A. Ground equipment according to Division 26 Section "Grounding and Bonding."
B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
3.4 FIELD QUALITY CONTROL

A. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
   1. Test cables for electrical continuity and insulation integrity before energizing.
   2. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.
   3. Testing shall be done per the latest IEEE Std. 515 test section and applicable manufacturer’s standards.
   4. In the field, all heater cables shall be meggered. The following separate field megger readings shall be taken on each self-regulating and each M.1 heater cable:
      a. Heater cable shall be meggered when received at jobsite before installation.
      b. Heater cable shall be meggered after installation, but before insulation is applied.
      c. Heater cable shall be meggered after insulation has been installed.
   5. All of the above field megger readings shall be greater than 20 megohms. Otherwise, the heater cable is not acceptable and shall be replaced.
   6. Field megger tests shall be recorded for each heater cable, and certified reports shall be submitted to the user.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounting cables.

C. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 230533
PART 1 - GENERAL

1.1 SUMMARY
A. This Section specified performance requirements for vibration control of all Division 23 components.
B. This Section includes the following products:
   1. Isolation Pads.
   2. Isolation Mounts – Code A.
   3. Freestanding Spring Isolators – Code B.
   4. Restraint Spring Isolators – Code C.
   6. Spring Hangers – Code D.
   7. Spring Hangers with Vertical-Limit Stops – Code E.
   9. Restrained Vibration Isolation Roof-Curb Rails – Code G.
  11. Snubbers.
  12. Acoustical Pipe Seal - Code M.
  13. All Directional Anchors - Code N.

1.2 DEFINITIONS
C. SMACNA: Sheet Metal and Air Conditioning Contractor’s National Association.
D. ASCE: American Society of Civil Engineers.

1.3 SUBMITTALS
A. Delegated-Design Submittal: Submit analysis data for vibration isolation and restraint work. Indicate compliance with performance requirements and design criteria. Data shall be signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Design Calculations: Calculate static and dynamic loading due to equipment weight, thermal expansion, equipment operation, forces required to select vibration isolators, restraints, and for designing vibration isolation bases.
   2. Pipe Riser Supports: Include piping riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that piping riser systems have been analyzed for excessive stress and that none will exist.
   3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
   4. Restraint Details:
      a. Design Analysis: To support selection and arrangement of restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during events. Indicate association with vibration isolation devices.

c. Coordinate vibration isolation details with wind-restraint details required for equipment mounted outdoors.

B. Product Data:
1. Submit rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of restraint components used.
   a. Annotate to indicate application of each product submitted and compliance with requirements.
3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

C. Coordination Drawings: Show coordination of bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports.

D. Welding certificates.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to Authorities Having Jurisdiction.

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Mason Industries.
   3. Vibro Acoustics
   4. Micro Metal

2.2 VIBRATION ISOLATORS

A. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
   1. Resilient Material: Oil- and water-resistant neoprene.
B. Isolation Mounts (Code A): Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
3. Product shall be equal to Mason Industries Type N or ND.

C. Spring Isolators (Code B): Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
7. Include holes in bottom plate for bolting unit to substrate.
8. Isolators exposed to weather shall be hot dipped galvanized.
9. Product shall be equal to Mason Industries type SLFH.

D. Restrained Spring Isolators (Code C): Freestanding, steel, open-spring isolators with limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Include holes in bottom plate for bolting unit to substrate.
8. Isolators exposed to weather shall be hot dipped galvanized.
9. Product shall be equal to Mason Industries Type SLR.

E. Spring Hangers (Code D): Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
8. Product shall be equal to Mason Industries, Type 30N.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
9. Product shall be equal to Mason Industries, Type PC30N.

G. All Directional Anchors (Code N): All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions. Product shall be equal to Mason Industries Type ADA.

H. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements. Product shall be equal to Mason Industries, Type VSG.

I. Acoustical Pipe Seal (Code M) (Acoustical Floor, Ceiling, and Wall Seals): Provide split seal consisting of two bolted pipe halves with 3/4 inch or thicker neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall, or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum of 1 inch past either face of the wall. Where temperatures exceed 240 degrees F, 10 lb. density fiberglass may be used in lieu of the sponge, equal to Mason Industries, Type SWS.
2.3 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS – CODE G

A. General Requirements for Restrained Vibration Isolation Roof-Curb Rails (Code G): Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand wind forces.

B. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Provide upper frame with continuous support for equipment, captive to resiliently resist forces. Provide lower support assembly with a means for attaching to building structure and a wood nailer for attaching roof materials, and insulated with a minimum of 2 inches (50 mm) of rigid, glass-fiber insulation on inside of assembly.

C. Spring Isolators: Adjustable, restrained spring isolators mounted on 1/4-inch- (6-mm-) thick, elastomeric vibration isolation pads with access ports for level adjustment, and removable waterproof covers at all isolator locations. Locate isolators such that they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with restraint.
   a. Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
   b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
   a. Resilient Material: Oil- and water-resistant neoprene.

D. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch (6 mm) thick.

E. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

F. Product shall be equal to Mason Industries, Type CMAB.

2.4 VIBRATION ISOLATION EQUIPMENT BASES

A. Steel Base (Code H): Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
   a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
   1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
      a. Include supports for suction and discharge elbows for pumps.
   2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.
   3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
   4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.5 FACTORY FINISHES
   A. Finish: Manufacturer's standard prime-coat finish ready for field painting.
   B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
      1. Powder coating on springs and housings.
      2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
      3. Baked enamel or powder coat for metal components on isolators for interior use.
      4. Color-code or otherwise mark vibration isolation-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine areas and equipment to receive vibration isolation and control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
   B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
   C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 VIBRATION CONTROL DEVICE INSTALLATION
   A. General: Supply vibration isolation products as scheduled on drawings and in accordance with ASHRAE Handbook, 2011 HVAC Applications Volume, Chapter "Noise and Vibration Control".
   B. Piping:
      1. All chilled water, condenser water, high temperature hot water, hot water, steam, refrigerant, domestic water, drain and engine exhaust piping that is connected to vibration-isolated equipment shall be isolated from the building structure within the following limits:
         a. Within mechanical rooms and boiler rooms.
         b. Within 50 feet total pipe length of connected vibration-isolated equipment (chillers, pumps, air handling units, pressure reducing stations, etc.).
2. Piping shall be isolated from the building structure by means of vibration isolation mounts, resilient pipe guides and resilient penetration sleeve/seals.

3. Isolators for the first three support points adjacent to connected equipment shall achieve one half the specified static deflection of the isolators supporting the connected equipment. When the required static deflection of these isolators in greater than 1/2 inch, Code C or Code E isolators shall be used. When the required static deflection is less than or equal to 1/2 inch, Type Code A or Code D1 isolators shall be used. All other pipe support isolators within the specified limits shall be either Code D or D1 achieving 0.25 inch static deflection.

4. For piping connected to equipment hanging from structure under occupied spaces, the first three hangers shall have 0.75 inch deflection for pipe sizes up to and including 3 inches, 1.5 inch deflection for pipe sizes up to and including 6 inches and 2.5 inch deflection thereafter. All other hangers and mounts shall have a minimum steel spring deflection of 0.75 inches. Hangers shall be located as close to the overhead supports as practical.

5. Where lateral support of pipe risers is required within the specified limits, this shall be accomplished by use of resilient lateral supports.

6. Pipes within the specified limits that penetrate the building structure shall be isolated from the building structure by use of Code M pipe seal.

7. Provide flexible pipe connections at all equipment mounted on vibration control products and wherever shown on the drawings.

8. Risers shall be suspended from or supported by Code E hangers or Code C mountings and the piping anchored or guided with Code N anchors. Steel spring deflections shall be a minimum of 0.75 inches except in those expansion locations where additional deflection is required to limit deflection or load changes to plus or minus 25 percent of the initial stress.

C. Ductwork:

1. All sheet metal ducts and air plenums that are within mechanical rooms or within a distance of 50 feet total duct length of connected vibration-isolated equipment (whichever is longer) shall be isolated from the building structure by Code A, fiberglass pads, or Code E isolators. All isolators shall achieve 0.1 inch minimum static deflection.

2. Where lateral support of duct risers is required within the specified limits, this shall be accomplished by use of resilient lateral support.

3. Ducts within the specified limits that penetrate the building construction shall be isolated from the building by use of resilient penetration sleeve/seals.

4. Provide flexible duct connections at all equipment mounted on vibration control products and wherever shown on the drawings.

D. Except as otherwise indicated, comply with manufacturer’s instructions for installation and load application to vibration control materials and units. Adjust to ensure that units have equal deflection, do not bottom out under loading and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.

E. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces and as indicated.

F. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

G. Install inertia base frames on isolator units as indicated, so that minimum of 1 inch clearance below base will result when frame is filled with concrete and supported equipment has been installed and loaded for operation. Provide concrete for inertial bases.
H. For air handling equipment, install thrust restraints as indicated and also wherever thrust exceeds 10 percent of equipment weight.
I. Locate isolation hangers as near overhead support structure as possible.
J. Weld riser isolator units in place as required to prevent displacement from loading and operations.
K. Flexible Pipe Connectors: Install on equipment side of shutoff valves, horizontally and parallel to equipment shafts wherever possible.

3.3 ADJUSTING
A. Adjust isolators after piping system is at operating weight.
B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
C. Adjust active height of spring isolators.
D. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.4 DEMONSTRATION
A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 230548
SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY
A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
   4. Duct labels.
   5. Stencils.
   6. Valve tags.
   7. Warning tags.

1.2 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.
B. Shop Drawings:
   1. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
   2. Valve numbering scheme.
   3. Valve Schedules: For each piping system to include in maintenance manuals.
C. Samples: For color, letter style, and graphic representation required for each identification material and device. For review by Owner and Engineer.

1.4 COORDINATION
A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
B. Coordinate installation of identifying devices with locations of access panels and doors.
C. Install identifying devices before installing acoustical ceilings and similar concealment.

1.5 QUALITY ASSURANCE
A. Codes and Standards:
   1. ANSI Standards: Comply with (ASME) ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS
A. Manufacturer: Subject to compliance with requirements, provide mechanical identification materials of one of the following:
2.2 EQUIPMENT LABELS

A. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 4 by 1 inch.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
9. Label Content: The label shall contain the following information:
   a. Equipment Tag Number or unique equipment number
   b. FMLH Asset Number
   c. BMS Address and VMA Number, as applicable.

B. Equipment Labels Example:

![Diagram of a label with the text AAP-CFAC-04-02]

C. Owner Asset Tags
1. All equipment shall be given asset tags.
2. The Contractor shall furnish a list of all Division 23 equipment being installed as part of the Contract within 30 days of Notice to Proceed. The list shall be on 8-1/2-by-11-inch (A4) bond paper and transmitted electronically by Microsoft Excel Spreadsheet. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules). Include all information required for the label noted above.
3. The Owner shall assign each piece of equipment a unique FMLH asset tag number. The information shall be provided to the Contractor in writing and electronic form.

4. The Owner shall furnish the asset tags to be installed by the Contractor.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Include all information required for the label. Equipment schedule shall be included in operation and maintenance data.

2.3 WARNING SIGNS AND LABELS
   A. Same as above for Equipment Labels with following changes:
      1. Letter Color: Black
      2. Background Color: Yellow.
      3. Label Content: Include caution and warning information, plus emergency notification instructions.

2.4 PIPE LABELS
   A. Pressure-Sensitive Type: Provide manufacturer's standard preprinted, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers, complying with ANSI (ASME) A13.1.
   B. Small Pipes: For external diameters less than 6 inch (including insulation if any), provide full-band pipe markers or sticker, extending 360 degrees around pipe at each location, fastened by one of the following methods:
      1. Adhesive lap joint in pipe marker overlap.
      2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4 inch wide; full circle at both ends of pipe marker, tape lapped 1-1/2 inch.
   C. Large Pipes: For external diameters of 6 inch and larger (including insulation if any), provide full-band pipe markers or sticker fastened by the following method:
      1. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2 inch wide; full circle at both ends of pipe marker, tape lapped 3 inch.
   D. Lettering: Comply with piping system nomenclature as specified, scheduled or shown, and abbreviate only as necessary for each application length.
   E. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.
   F. Pipe Label Color Schedule:
      1. Chilled Water Piping:
         a. Background Color: Green.
      2. Condenser Water Piping:
         a. Background Color: Yellow.
      3. Heating Water Piping:
         a. Background Color: Yellow.
         b. Letter Color: Black.
4. Refrigerant Piping:
   a. Background Color: Blue.

5. Low Pressure Steam Piping:
   a. Background Color: Yellow.
   b. Letter Color: Black.

6. High Pressure Steam Piping:
   a. Background Color: Yellow.
   b. Letter Color: Black.

7. Steam Condensate Piping:
   a. Background Color: Yellow.
   b. Letter Color: Black.

2.5 UNDERGROUND-TYPE PLASTIC LINE MARKERS

A. General: Manufacturer's standard permanent, bright-colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6 inch wide x 4 mils thick. Provide tape with printing which most accurately indicates type of service of buried pipe.
   
   1. Provide multiply tape consisting of solid aluminum foil core between 2 layers of plastic tape.

2.6 DUCT LABELS

A. General: Provide manufacturer’s standard laminated plastic, color coded duct markers. Conform to the following color code:
   
   2. Blue: Outside, return, and mixed air.
   3. For General Exhaust: Black Letters on Yellow Background.
   4. For hazardous exhausts, use Red labels with white letters.

B. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

C. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

D. Minimum Letter Size: 1-1/2 inch (39 mm).

E. Fasteners: Stainless-steel rivets or self-tapping screws.

F. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

G. Duct Label Contents: Include system type in accordance with systems outline in Paragraph 2.6A, and an arrow indicating flow direction.
   
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches (38 mm) high.

2.7 LIFE SAFETY DAMPER LABELS

A. Provide a label at the access panel for every fire damper, smoke damper and combination fire/smoke damper.
B. The label shall be red with white lettering. The lettering shall be a minimum of 1-inch in height.
C. The label content shall state 'FIRE DAMPER,' "SMOKE DAMPER," or "FIRE/SMOKE DAMPER" No abbreviations are allowed.

2.8 STENCILS
A. Stencils:
   1. Height: Minimum 4 inches (100 mm).
   3. Stencil Paint: Exterior, rust preventative, gloss, acrylic enamel, Rust-Oleum V2100 System Enamel Paint or equal approved in writing by owner. Paint may be in pressurized spray-can form.
   4. Identification Paint: Exterior, rust preventative, gloss, acrylic enamel, semi-gloss black paint. Shall be Rust-Oleum V2100 System Enamel Paint or equal approved in writing by owner. Paint may be in pressurized spray-can form.

2.9 VALVE TAGS
A. Valve Tags: Stamped or engraved with 3/16 inch (6.4 mm) letters for piping system abbreviation and 3/8 inch (13 mm) numbers.
B. Plastic Valve Tags: Provide manufacturer’s standard solid plastic valve tags with printer enamel lettering, with piping system abbreviation in approximately 3/16 inch high letters and sequenced valve numbers approximately 3/8 inch high, and with 5/32 inch hole for fasteners.
   1. Provide tags sufficient for the lettering and installation of FMLH asset tag.
   2. The tag color shall match piping system color noted in Paragraph 2.3 above.
C. Valve Tag Fasteners: Provide manufacturer’s standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.
D. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Valve-tag schedule shall be included in operation and maintenance data.
E. Provide a label for each valve with a FMLH asset tag number as follows:
   1. The label shall be minimum 1/2” high
   2. Lettering shall be black on white background, minimum 40 points high, boldface, sans serif type
   3. The label shall contain the following information:
      a. Equipment Tag Number or unique equipment number
      b. FMLH Asset Number
      c. BMS Address and VMA Number, as applicable.
   4. The label shall be affixed to the pipe adjacent to the valve
2.10 WARNING TAGS
A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: 3 by 5-1/4 inches (75 by 133 mm) minimum.
   2. Fasteners: Brass grommet and wire.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

2.11 CEILING MARKERS
A. Provide a label for each piece of equipment with a FMLH asset tag from an industrial label maker and printer. The label shall be as follows:
   1. The label shall be minimum 1/2" high
   2. Lettering shall be black on clear background, minimum 40 points, boldface, sans serif type
   3. The label shall contain the following information:
      a. Equipment Tag Number or unique equipment number
      b. FMLH Asset Number
      c. BMS Address and VMA Number, as applicable.

2.12 LETTERING AND GRAPHICS
A. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of mechanical systems and equipment.
B. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (as examples; Boiler No. 3, Air Handling Unit No. 1H).
C. Submit for review and approval by Owner and Architect lettering and graphics to be used on this project.

PART 3 - EXECUTION
3.1 PREPARATION
A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION
A. Interior and exterior equipment:
   1. Install or permanently fasten labels on each major item of mechanical equipment.
   2. Locate equipment labels where accessible and visible.
3. Install nameplates on or near each major item of mechanical equipment and each operational device, as specified herein if not otherwise specified for each item or device. Provide signs for the following general categories of equipment:

a. Fuel burning units including boilers, furnaces, heaters, stills and absorption units.
b. Pumps, compressors, chillers, condensers and similar motor driven units.
c. Heat exchangers, coils, evaporators, cooling towers, heat recovery units and similar equipment.
d. Fans, blowers, primary balancing dampers and mixing boxes.
e. Packaged HVAC central station and zone type units.
f. Tanks and pressure vessels.

B. Exterior Equipment: In addition to the requirements above, the Contractor shall perform the following additional identification for exterior equipment:

1. Stencil the equipment identification to the unit.
2. Provide a 12 inch (250 mm) wide band of yellow, semi-gloss paint for all general service exhaust fans.
3. Provide a 12 inch (250 mm) wide band of red, semi-gloss paint for all fans associated with hazardous exhaust. The Owner may request alternate colors for fans serving special hazards.

3.3 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Division 09 Section "Finishes."

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.

3.4 DUCT LABEL INSTALLATION

A. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 25 feet (15 m) in each space where ducts are exposed or concealed by removable ceiling system.

1. Near each branch connection, excluding short takeoffs for terminal units. Where flow pattern is not obvious, mark each branch.
2. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
3. At access doors, manholes, and similar access points that permit view of concealed ductwork.
4. Near major equipment items and other points of origination and termination.

B. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.

C. Install duct labels on all duct access doors providing access to fire dampers, smoke dampers, and combination smoke fire dampers. Provide label reading "Fire Damper", "Smoke Damper", or "Smoke/Fire Damper" as required by the application.
3.5 VALVE TAG INSTALLATION
   A. Install tags on valves and control devices in piping systems, except check valves; valves within
      factory fabricated equipment units; shutoff valves and HVAC terminal devices and similar
      roughing-in connections of end use fixtures and units. List tagged valves in a valve schedule.
   B. Valve Tag Application Schedule: Tag valves according to size, shape, and color scheme and
      with captions similar to those indicated.

3.6 WARNING TAG INSTALLATION
   A. Write required message on, and attach warning tags to, equipment and other items where
      required.

3.7 CEILING MARKER INSTALLATION
   A. Install ceiling markers at valves, equipment and fire dampers.

END OF SECTION 230553
SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes TAB to produce design objectives for the following:
   1. Air Systems:
      a. Constant-volume air systems.
      b. Variable-air-volume systems.
      c. General exhaust systems.
      d. Specialty exhaust systems.
   2. Hydronic Piping Systems:
      a. Constant-flow systems.
      b. Variable-flow systems.
      c. Primary-secondary systems.
   3. Steam systems.
   4. HVAC equipment quantitative-performance settings.
   6. Laboratory fume hood airflow balancing.
   7. Exhaust hood airflow balancing.
   8. Space pressurization testing and adjusting.
   10. Sound level measuring.
   11. Stair-tower pressurization testing and adjusting.
   12. Smoke-control systems testing and adjusting.
   13. Indoor-air quality measuring.
   14. Existing systems TAB.
   15. Verifying that automatic control devices are functioning properly.
   16. Reporting results of activities and procedures specified in this Section.

1.2 DEFINITIONS
A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
B. Balance: To proportion flows within the distribution system, including sub mains, branches, and terminals, according to indicated quantities.
C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.
D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
E. NC: Noise criteria.
F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
G. RC: Room criteria.

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H. Report Forms: Test data sheets for recording test data in logical order.
I. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.
J. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.
K. Stair Pressurization System: A type of smoke-control system that is intended to positively pressurize stair towers with outdoor air by using fans to keep smoke from contaminating the stair towers during an alarm condition.
L. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
M. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.
N. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
O. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
P. TAB: Testing, adjusting, and balancing.
Q. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
R. Test: A procedure to determine quantitative performance of systems or equipment.
S. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.3 SUBMITTALS
B. Strategies and Procedures Plan: Within 30 days from Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.
C. Certified TAB Reports: Submit reports prepared, as specified in this Section, on approved forms certified by TAB firm.
D. Sample Report Forms: Submit two sets of sample TAB report forms.
E. Warranties specified in this Section.

1.4 QUALITY ASSURANCE
A. TAB Firm Qualifications: Engage a TAB firm certified by AABC or NEBB.
B. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven (7) days' advance notice of scheduled meeting time and location.
1. Agenda Items: Include at least the following:
a. Submittal distribution requirements.
c. TAB plan.
d. Work schedule and Project-site access requirements.
e. Coordination and cooperation of trades and subcontractors.
f. Coordination of documentation and communication flow.

C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard forms from:

E. Instrumentation Type, Quantity, and Accuracy: As described in:

F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.5 PROJECT CONDITIONS
A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.6 COORDINATION
A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven (7) days advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.
1.7 WARRANTY

A. The Balancing Contractor shall be bound by the project guarantee period which shall start after acceptance of test and balance work. During this time the Engineer, at his discretion, may request a recheck or resetting of any outlet, supply air fan, or exhaust fan as necessary to balance occupancy loads or specific operating characteristics of the job.

PART 2 - PRODUCTS

2.1 TESTING, ADJUSTING AND BALANCING CONTRACTOR REQUIREMENTS

A. The Testing, Adjusting and Balancing Contractor shall meet the following requirements:
   1. Selected from an approved list provided by Froedtert Hospital Facilities Management.
   2. The Contractor shall not be affiliated with any mechanical contracting company in name or financial arrangement unless approved in writing by the Owner.

B. Contractors: subject to compliance with the remainder of the Contract Requirements select Testing, Adjusting and Balancing Services from the list of Contractors:
   1. Arends Balancing and Commissioning, Inc.
   2. International Test & Balance
   3. Accustar Air Balance
   4. Other TAB Contractor approved in writing by Froedtert Hospital Facilities Management.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
   1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
   2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 01 Section "Project Record Documents."

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.
F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

M. Examine strainers for clean screens and proper perforations.

N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

P. Examine system pumps to ensure absence of entrained air in the suction piping.

Q. Examine equipment for installation and for properly operating safety interlocks and controls.

R. Examine automatic temperature system components to verify the following:
   1. Dampers, valves, and other controlled devices are operated by the intended controller.
   2. Dampers and valves are in the position indicated by the controller.
   3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
   4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
   5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
   6. Sensors are located to sense only the intended conditions.
   7. Sequence of operation for control modes is according to the Contract Documents.
   8. Controller set points are set at indicated values.
   9. Interlocked systems are operating.
  10. Changeover from heating to cooling mode occurs according to indicated values.

S. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.
B. Complete system readiness checks and prepare system readiness reports. Verify the following:
   1. Permanent electrical power wiring is complete.
   2. Hydronic systems are filled, clean, and free of air.
   3. Automatic temperature-control systems are operational.
   4. Equipment and duct access doors are securely closed.
   5. Balance, smoke, and fire dampers are open.
   6. Isolating and balancing valves are open and control valves are operational.
   7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
   8. Windows and doors can be closed so indicated conditions for system operations can be met.

### 3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in:
   1. AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in:
   1. Inch-pound (IP).

### 3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems’ "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.
K. Check for proper sealing of air-handling unit components.
L. Check for proper sealing of air duct system.
M. Do not adjust the calibration of supply, return or exhaust air valves to align with measured air flows.
N. Replace all variable-pitch sheaves are used for balancing with fixed-pitch sheaves, unless variable-pitch sheaves are explicitly allowed for the specific piece of equipment.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:
   a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
   b. Measure static pressure directly at the fan outlet or through the flexible connection.
   c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
   d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, exhaust fan and other air-handling and -treating equipment.
   a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.
4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective actions.
5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to obtain design airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
   a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the branch with terminal units that are most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units in critical branch at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
   a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record the final fan performance data.

C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Balance systems similar to constant-volume air systems.
2. Set terminal units and supply fan at full-airflow condition.
3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.

4. Readjust fan airflow for final maximum readings.

5. Measure operating static pressure at the sensor that controls the supply fan, if one is installed, and verify operation of the static-pressure controller.

6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.

7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
   a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check expansion tank liquid level.
3. Check makeup-water-station pressure gage for adequate pressure at coil.
4. Check flow-control valves for specified sequence of operation and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR HYDRONIC SYSTEMS

A. Hydronic balancing shall follow system flush and cleaning of strainers.

B. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.

4. Report flow rates that are not within plus or minus 5 percent of design.

C. Set calibrated balancing valves, if installed, at calculated presettings.

D. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

E. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

F. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

G. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

H. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.10 PROCEDURES FOR PRIMARY-SECONDARY-FLOW HYDRONIC SYSTEMS

A. Balance the primary system crossover flow first; then balance the secondary system.

3.11 PROCEDURES FOR STEAM SYSTEMS

A. Measure and record upstream and downstream pressure of each piece of equipment.

B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.

C. Check the setting and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record the final setting.

D. Check the settings and operation of each safety valve. Record settings.

E. Verify the operation of each steam trap.

3.12 PROCEDURES FOR HEAT EXCHANGERS

A. Measure water flow through all circuits.

B. Adjust water flow to within specified tolerances.

C. Measure inlet and outlet water temperatures.

D. Measure inlet steam pressure.
E. Check the setting and operation of safety and relief valves. Record settings.

3.13 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer, model, and serial numbers.
   4. Efficiency rating.
   5. Nameplate and measured voltage, each phase.
   6. Nameplate and measured amperage, each phase.
   7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.14 PROCEDURES FOR CHILLERS

A. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
   1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
   2. If water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
   3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
   4. Power factor if factory-installed instrumentation is furnished for measuring kilowatt.
   5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatt.
   7. If air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.15 PROCEDURES FOR COOLING TOWERS

A. Shut off makeup water for the duration of the test, and verify that makeup and blowdown systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:
   1. Measure condenser-water flow to each cell of the cooling tower.
   2. Measure entering- and leaving-water temperatures.
   3. Measure wet- and dry-bulb temperatures of entering air.
   4. Measure wet- and dry-bulb temperatures of leaving air.
   5. Measure condenser-water flow rate recirculating through the cooling tower.
   6. Measure cooling tower pump discharge pressure.
   7. Adjust water level and feed rate of makeup-water system.

3.16 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.
B. Measure entering- and leaving-air temperatures.
C. Record compressor data.

3.17 PROCEDURES FOR BOILERS
A. If hydronic, measure entering- and leaving-water temperatures and water flow.
B. If steam, measure entering-water temperature and flow and leaving steam pressure, temperature, and flow.

3.18 PROCEDURES FOR HEAT-TRANSFER COILS
A. Water Coils: Measure the following data for each coil:
   1. Entering- and leaving-water temperature.
   2. Water flow rate.
   3. Water pressure drop.
   4. Dry-bulb temperature of entering and leaving air.
   5. Wet-bulb temperature of entering and leaving air for cooling coils.
   6. Airflow.
   7. Air pressure drop.
B. Electric-Heating Coils: Measure the following data for each coil:
   1. Nameplate data.
   2. Airflow.
   3. Entering- and leaving-air temperature at full load.
   4. Voltage and amperage input of each phase at full load and at each incremental stage.
   5. Calculated kilowatt at full load.
   6. Fuse or circuit-breaker rating for overload protection.
C. Steam Coils: Measure the following data for each coil:
   1. Dry-bulb temperature of entering and leaving air.
   2. Airflow.
   3. Air pressure drop.
   4. Inlet steam pressure.
D. Refrigerant Coils: Measure the following data for each coil:
   1. Dry-bulb temperature of entering and leaving air.
   2. Wet-bulb temperature of entering and leaving air.
   3. Airflow.
   4. Air pressure drop.
   5. Refrigerant suction pressure and temperature.

3.19 PROCEDURES FOR TEMPERATURE MEASUREMENTS
A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.
B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.
3.20 PROCEDURES FOR COMMERCIAL KITCHEN HOODS

A. Measure, adjust, and record the airflow of each kitchen hood. For kitchen hoods designed with integral makeup air, measure and adjust the exhaust and makeup airflow. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, provide an explanation in the report of the reason(s) why and also the reason why the method used was chosen.

1. Install welded test ports in the sides of the exhaust duct for the duct Pitot-tube traverse. Install each test port with a threaded cap that is liquid tight.

B. After balancing is complete, do the following:

1. Measure and record the static pressure at the hood exhaust-duct connection.
2. Measure and record the hood face velocity. Make measurements at multiple points across the face of the hood. Perform measurements at a maximum of 12 inches (300 mm) between points and between any point and the perimeter. Calculate the average of the measurements recorded. Verify that the hood average face velocity complies with the Contract Documents and governing codes.
3. Check the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to room airflow patterns to achieve optimum results.

C. Visually inspect the hood exhaust duct throughout its entire length in compliance with authorities having jurisdiction. Begin at the hood connection and end at the point it discharges outdoors. Report findings.

1. Check duct slopes as required.
2. Verify that duct access is installed as required.
3. Verify that point of termination is as required.
4. Verify that duct air velocity is within the range required.
5. Verify that duct is within a fire-rated enclosure.

D. Report deficiencies.

3.21 PROCEDURES FOR LABORATORY FUME HOODS

A. Before performing laboratory fume hood testing, measure, adjust and record the supply airflow and airflow patterns of each supply air outlet that is located in the same room as the hood. Adjust the air outlet flow pattern to minimize turbulence and to achieve the desired airflow patterns at the face and inside the hood. Verify that adequate makeup air is available to achieve the indicated flow of the hood.

B. Measure, adjust, and record the airflow of each laboratory fume hood by duct Pitot-tube traverse with the laboratory fume hood sash in the design open position.

1. For laboratory fume hoods installed in variable exhaust systems, measure, adjust, and record the hood exhaust airflow at maximum and at minimum airflow conditions.
2. For laboratory fume hoods designed with integral makeup air, measure, adjust, and record the exhaust and makeup airflow.

C. For laboratory fume hoods that are connected to centralized exhaust systems using automatic dampers, adjust the damper controller to obtain the indicated exhaust airflow.

D. Do not adjust the calibration of supply, return or exhaust air valves to align with measured air flows.
E. After balancing is complete, do the following:
   1. Measure and record the static pressure at the hood duct connection with the hood operating at indicated airflow.
   2. Measure and record the face velocity across the open sash face area. Measure the face velocity at each point in a grid pattern. Perform measurements at a maximum of 12 inches (300 mm) between points and between any point and the perimeter of the opening.
      a. For laboratory fume hoods designed to maintain a constant face velocity at varying sash positions, also measure and record the face velocity at 50 and 25 percent of the design open sash position.
      b. Calculate and report the average face velocity by averaging all velocity measurements.
      c. Calculate and report the exhaust airflow by multiplying the calculated average face velocity by the sash open area. Compare this quantity with the exhaust airflow measured by duct Pitot-tube traverse. Report differences.
      d. If the average face velocity is less than the indicated face velocity, retest the average face velocity and adjust hood baffles, fan drives, and other parts of the system to provide the indicated average face velocity.
   3. Check each laboratory fume hood for the capture and containment of smoke by using a hand-held emitting device. Observe the capture and containment of smoke flow pattern across the open face and inside the hood. Make adjustments necessary to achieve the desired results.

F. With the room and laboratory fume hoods operating at indicated conditions, perform an "as-installed" performance test of the laboratory fume hood according to ASHRAE 110. Test [each] <insert number> laboratory fume hood(s) and document the test results.

3.22 PROCEDURES FOR EXHAUST HOODS
A. Measure, adjust, and record the airflow of each exhaust hood. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, explain why, in the report, and explain the test method used.

B. After balancing is complete, do the following:
   1. Measure and record the static pressure at the hood exhaust-duct connection.
   2. Check the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to achieve optimum results.

3.23 PROCEDURES FOR SPACE PRESSURIZATION MEASUREMENTS AND ADJUSTMENTS
A. Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable safing, gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.

B. Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.

C. Measure space pressure differential where pressure is used as the design criteria, and measure airflow differential where differential airflow is used as the design criteria for space pressurization.
   1. For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.
2. For applications with cascading levels of space pressurization, begin in the most critical space and work to the least critical space.

3. Test room pressurization first, then zones, and finish with building pressurization.

D. To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure or airflow difference.

E. For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.

1. Compare the values of the measurements taken to the measured values of the control system instruments and report findings.

2. Check the repeatability of the controls by successive tests designed to temporarily alter the ability to achieve space pressurization. Test overpressurization and underpressurization, and observe and report on the system's ability to revert to the set point.

3. For spaces served by variable-air-volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.

F. In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.

G. Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.24 PROCEDURES FOR VIBRATION MEASUREMENTS

A. Use a vibration meter meeting the following criteria:

1. Solid-state circuitry with a piezoelectric accelerometer.

2. Velocity range of 0.1 to 10 inches per second (2.5 to 254 mm/s).

3. Displacement range of 1 to 100 mils (0.0254 to 2.54 mm).

4. Frequency range of at least 0 to 1000 Hz.

5. Capable of filtering unwanted frequencies.

B. Calibrate the vibration meter before each day of testing.

1. Use a calibrator provided with the vibration meter.

2. Follow vibration meter and calibrator manufacturer's calibration procedures.

C. Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not influence measurements of equipment being tested.

1. Turn off equipment in the building that might interfere with testing.

2. Clear the space of people.

D. Perform vibration measurements after air and water balancing and equipment testing is complete.

E. Clean equipment surfaces in contact with the vibration transducer.

F. Position the vibration transducer according to manufacturer's written instructions and to avoid interference with the operation of the equipment being tested.

G. Measure and record vibration on rotating equipment over 3 hp (2.2 kW).
H. Measure and record equipment vibration, bearing vibration, equipment base vibration, and building structure vibration. Record velocity and displacement readings in the horizontal, vertical, and axial planes.

1. Pumps:
   a. Pump Bearing: Drive end and opposite end.
   b. Motor Bearing: Drive end and opposite end.
   c. Pump Base: Top and side.
   d. Building: Floor.
   e. Piping: To and from the pump after flexible connections.

2. Fans and HVAC Equipment with Fans:
   a. Fan Bearing: Drive end and opposite end.
   b. Motor Bearing: Drive end and opposite end.
   c. Equipment Casing: Top and side.
   d. Equipment Base: Top and side.
   e. Building: Floor.
   f. Ductwork: To and from equipment after flexible connections.
   g. Piping: To and from equipment after flexible connections.

3. Chillers and HVAC Equipment with Compressors:
   a. Compressor Bearing: Drive end and opposite end.
   b. Motor Bearing: Drive end and opposite end.
   c. Equipment Casing: Top and side.
   d. Equipment Base: Top and side.
   e. Building: Floor.
   f. Piping: To and from equipment after flexible connections.

I. For equipment with vibration isolation, take floor measurements with the vibration isolation blocked solid to the floor and with the vibration isolation floating. Calculate and report the differences.

J. Inspect, measure, and record vibration isolation.

   1. Verify that vibration isolation is installed in the required locations.
   2. Verify that installation is level and plumb.
   3. Verify that isolators are properly anchored.
   4. For spring isolators, measure the compressed spring height, the spring OD, and the travel-to-solid distance.
   5. Measure the operating clearance between each inertia base and the floor or concrete base below. Verify that there is unobstructed clearance between the bottom of the inertia base and the floor.

3.25 PROCEDURES FOR SOUND-LEVEL MEASUREMENTS

A. Perform sound-pressure-level measurements with an octave-band analyzer complying with ANSI S1.4 for Type 1 sound-level meters and ANSI S1.11 for octave-band filters. Comply with requirements in ANSI S1.13, unless otherwise indicated.

B. Calibrate sound meters before each day of testing. Use a calibrator provided with the sound meter complying with ANSI S1.40 and that has NIST certification.

C. Use a microphone that is suitable for the type of sound levels measured. For areas where air velocities exceed 100 fpm (0.51 m/s), use a windscreen on the microphone.
D. Perform sound-level testing after air and water balancing and equipment testing are complete.
E. Close windows and doors to the space.
F. Perform measurements when the space is not occupied and when the occupant noise level from other spaces in the building and outside are at a minimum.
G. Clear the space of temporary sound sources so unrelated disturbances will not be measured. Position testing personnel during measurements to achieve a direct line-of-sight between the sound source and the sound-level meter.
H. Take sound measurements at a height approximately 48 inches (1200 mm) above the floor and at least 36 inches (900 mm) from a wall, column, and other large surface capable of altering the measurements.
I. Take sound measurements in dBA and in each of the 8 unweighted octave bands in the frequency range of 63 to 8000 Hz.
J. Take sound measurements with the HVAC systems off to establish the background sound levels and take sound measurements with the HVAC systems operating.
   1. Calculate the difference between measurements. Apply a correction factor depending on the difference and adjust measurements.
K. Perform sound testing at locations on Project for each of the following space types. For each space type tested, select a measurement location that has the greatest sound level. If testing multiple locations for each space type, select at least one location that is near and at least one location that is remote from the predominant sound source. The count and list of locations will be determined by Froedtert Faculties Management Staff in writing.

3.26 PROCEDURES FOR STAIR-TOWER PRESSURIZATION SYSTEM MEASUREMENTS AND ADJUSTMENTS
A. Before testing, observe the stair tower to verify that construction is complete. Verify the following:
   1. Walls and ceiling are free of unintended openings and are capable of achieving a pressure boundary.
   2. Firestopping and sealants are installed.
   3. Doors, door closers, and door gaskets are installed and adjusted.
   4. If applicable, window installation is complete.
B. Measure and record wind speed and direction, outside-air temperature, and relative humidity on each test day.
C. Test each stair tower as a single system. If multiple fans serve a single stair tower, operate the fans together.
D. Air Balance:
   1. Open the doors indicated to be open and measure, adjust, and record the airflow of each:
      a. Stair-tower fan.
      b. Air outlet supplying the stair tower.
   2. For ducted systems, measure the fan airflow by duct Pitot-tube traverse.
E. Pressurization Test:
   1. After air balancing is complete, perform stair-tower pressurization tests.
2. Establish a consistent procedure for recording data throughout the entire test. Set the stair-tower side of the doors as the reference point and the floor side of the doors with positive pressure when higher than the stair tower, and negative pressure when lower than the stair tower.

3. With the HVAC systems operating in their normal mode of operation and the stair-tower pressurization systems off, measure and record the following:
   a. Pressure difference across each stair-tower door with all doors in the stairwell closed.
   b. Force necessary to open each door, using a spring-type scale.

4. With the HVAC systems operating and the stair-tower pressurization system activated, perform the following:
   a. Place building HVAC systems in their normal operating mode including equipment not used to implement smoke control, such as air-handling units, toilet exhaust fans, fan coil units, and similar equipment.
   b. Measure and record the pressure difference across each stair-tower door with all doors in the stair tower closed. Adjust the stair-tower pressure relief to prevent overpressurization.
   c. Use a spring scale to measure and record the force needed to open the door closest to the fan. With the initial door held in the open position, measure and record the pressure difference across each remaining closed stair-tower door.
   d. Open additional doors (up to the number indicated) one at a time, and measure and record the pressure difference across each remaining closed stair-tower door after the opening of each additional door.
   e. Open the doors indicated to be open and measure and record the direction and velocity through each of the open doors by a traverse of every 1 sq. ft grid of door opening.
   f. Calculate the average of the door velocity measurements. Compare the average velocity to the Contract Documents and governing code requirements.

5. Repeat the pressurization tests with the smoke-control systems and the HVAC systems operating.

6. Criteria for Acceptance:
   a. The opening force on any door shall not exceed 30 lbf.
   b. Code requirements.

F. Operational Tests:

1. Check the proper activation of the stair-tower pressurization system(s) in response to all means of activation, both automatic and manual.

2. Verify that each initiating occurrence produces the proper system response under each of the following modes of operation:
   a. Normal.
   b. Alarm.
   d. Return to normal.

3. Verify that the smoke detector at the stair pressurization fan inlet de-energizes the fan and closes the damper at the fan.

4. If standby power is provided for stair pressurization systems, test to verify that the stair pressurization systems operate while on both normal and standby power.

5. Conduct additional tests required by authorities having jurisdiction.
G. Prepare a complete report of observations, measurements, and deficiencies.

3.27 PROCEDURES FOR SMOKE-CONTROL SYSTEM TESTING

A. Before testing smoke-control systems, verify that construction is complete and verify the integrity of each smoke-control zone boundary. Verify that windows and doors are closed and that applicable safing, gasket, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.

B. Measure and record wind speed and direction, outside-air temperature, and relative humidity on each test day.

C. Measure, adjust, and record airflow of each smoke-control system with all fans that are a part of the system operating as intended by the design.

D. Measure, adjust, and record the airflow of each fan. For ducted systems, measure the fan airflow by duct Pitot-tube traverse.

E. After air balancing is complete, perform the following pressurization testing for each smoke-control zone in the system:
   1. Verify the boundaries of each smoke-control zone.
   2. With the HVAC systems in their normal mode of operation and smoke control not operating, measure and record the pressure difference across each smoke-control zone. Make measurements after closing doors that separate the zones. Make one measurement across each door. Clearly indicate the high and low pressure side of each door.
   3. With the system operating in the smoke-control mode and with each zone in the smoke-control system activated, perform the following:
      a. Measure and record the pressure difference across each door that separates the smoke zone from adjacent zones. Make measurements with doors that separate the smoke zone from the other zones closed. Clearly indicate the high and low pressure side of the door. Doors that have a tendency to open slightly due to the pressure difference should have one pressure measurement made while held closed and another measurement made with the door open.
      b. Continue to activate each separate zoned smoke-control system and make pressure difference measurements.
      c. After testing a smoke zone's smoke-control system, deactivate the HVAC systems involved and return them to their normal operating mode before activating another zone's smoke-control system.
      d. Verify that controls necessary to prevent excessive pressure differences are functional.

F. Operational Tests:
   1. Check the proper activation of each zoned smoke-control system in response to all means of activation, both automatic and manual.
   2. Check automatic activation in response to fire alarm signals received from the building's fire alarm and detection system. Initiate a separate alarm for each means of activation to ensure that the proper operation of the correct zoned smoke-control system occurs.
   3. Check and record the proper operation of fans, dampers, and related equipment as outlined below for each separate zone of the smoke-control system.
      a. Fire zone in which a smoke-control system automatically activates.
      b. Type of signal that activates a smoke-control system, such as pull station, sprinkler water flow, or smoke detector.
c. Smoke zone(s) where maximum mechanical exhaust to the outside is implemented and no supply air is provided.
d. Positive pressure smoke-control zone(s) where maximum air supply is implemented and no exhaust to the outside is provided.
e. Fan(s) "ON" as required to implement the smoke-control system. Multiple- or variable-speed fans should be further noted as "MAX. VOLUME" to verify that the intended control configuration is achieved.
f. Fan(s) "OFF" as required to implement the smoke-control system.
g. Damper(s) "OPEN" where maximum airflow must be achieved.
h. Damper(s) "CLOSED" where no airflow should take place.
i. Auxiliary functions to achieve the smoke-control system configuration such as changes or override of normal operating pressure and temperature-control set points.
j. If standby power is provided for the smoke-control system, test to verify that the system functions while operating under both normal and standby power.

G. Conduct additional tests required by authorities having jurisdiction. Unless required by authorities having jurisdiction, perform testing without the use of smoke or products that simulate smoke.

H. Prepare a complete report of observations, measurements, and deficiencies.

3.28 PROCEDURES FOR INDOOR-AIR QUALITY MEASUREMENTS
A. After air balancing is complete and with HVAC systems operating at indicated conditions, perform indoor-air quality testing.
B. Observe and record the following conditions for each HVAC system:
   1. The distance between the outside-air intake and the closest exhaust fan discharge, cooling tower, flue termination, or vent termination.
   2. Specified filters are installed. Check for leakage around filters.
   3. Cooling coil drain pans have a positive slope to drain.
   4. Cooling coil condensate drain trap maintains an air seal.
   5. Evidence of water damage.
   6. Insulation in contact with the supply, return, and outside air is dry and clean.
C. Measure and record indoor conditions served by each HVAC system. Make measurements at multiple locations served by the system if required to satisfy the following:
   1. Most remote area.
   2. One location per floor.
   3. One location for every 5000 sq. ft. (500 sq. m).
D. Measure and record the following indoor conditions for each location two times at two-hour intervals, and in accordance with ASHRAE 113:
   1. Temperature.
   2. Relative humidity.
   3. Air velocity.
   5. Concentration of carbon monoxide (ppm).
   7. Formaldehyde (ppm).
3.29 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
   1. Measure and record the operating speed, airflow, and static pressure of each fan.
   2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
   3. Check the refrigerant charge.
   4. Check the condition of filters.
   5. Check the condition of coils.
   6. Check the operation of the drain pan and condensate drain trap.
   7. Check bearings and other lubricated parts for proper lubrication.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished.
   1. New filters are installed.
   2. Coils are clean and fins combed.
   3. Drain pans are clean.
   4. Fans are clean.
   5. Bearings and other parts are properly lubricated.
   6. Deficiencies noted in the preconstruction report are corrected.

C. Pre-Construction Testing
   1. Prior to the beginning of demolition or construction, perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
      a. Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan, speed, filter, and coil face velocity.
      b. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
      c. If calculations increase or decrease the airflow and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated airflow and water flow rates. If 5 percent or less, equipment adjustments are not required.
      d. Air balance each air outlet.

3.30 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.
H. Check the interaction of interlock and lockout systems.
I. Check main control supply-air pressure and observe compressor and dryer operations.
J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.
K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.31 TOLERANCES
A. Set HVAC system airflow and water flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to minus 2 percent.
   2. Supply, Return and Exhaust Diffusers, Registers and Grilles: plus or minus 10 percent.
   3. Critical Area Supply, Return and Exhaust Diffusers, Registers and Grilles:
      a. Positively Pressurized Areas:
         1) Supply: plus 5 to minus 0 percent.
         2) Return and Exhaust: plus 0 to minus 5 percent.
      b. Negatively Pressurized Areas:
         1) Supply: plus 0 to minus 5 percent.
         2) Return and Exhaust: plus 5 to minus 0 percent.
      c. Refer to Ventilation Schedules for identification of critical spaces.
   4. Exhaust Hood Face Velocity: plus or minus 5 percent
   5. Heating-Water Flow Rate: plus or minus 5 percent.
   6. Cooling-Water Flow Rate: plus or minus 5 percent.

3.32 REPORTING
A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Provide preliminary balance report for each system and each building floor as completed. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.33 FINAL REPORT
A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
   1. Include a list of instruments used for procedures, along with proof of calibration.
C. Final Report Contents: In addition to certified field report data, include the following:
   1. Pump curves.
2. Fan curves.
3. Manufacturers’ test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of TAB firm.
3. Project name.
4. Project location.
5. Architect’s name and address.
6. Engineer’s name and address.
7. Contractor’s name and address.
9. Signature of TAB firm who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
   a. Indicated versus final performance.
   b. Notable characteristics of systems.
   c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer, type size, and fittings.
14. Notes to explain why certain final data in the body of reports varies from indicated values.
15. Test conditions for fans and pump performance forms including the following:
   a. Settings for outside-, return-, and exhaust-air dampers.
   b. Conditions of filters.
   c. Cooling coil, wet- and dry-bulb conditions.
   d. Face and bypass damper settings at coils.
   e. Fan drive settings including settings and percentage of maximum pitch diameter.
   f. Settings for supply-air, static-pressure controller.
   g. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.

F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data: Include the following:
   a. Unit identification.
   b. Location.
   c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches (mm), and bore.
i. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
j. Number of belts, make, and size.
k. Number of filters, type, and size.

2. Motor Data:
   a. Make and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches (mm), and bore.
   f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm (L/s).
   b. Total system static pressure in inches wg (Pa).
   c. Fan rpm.
   d. Discharge static pressure in inches wg (Pa).
   e. Filter static-pressure differential in inches wg (Pa).
   f. Preheat coil static-pressure differential in inches wg (Pa).
   g. Cooling coil static-pressure differential in inches wg (Pa).
   h. Heating coil static-pressure differential in inches wg (Pa).
   i. Outside airflow in cfm (L/s).
   j. Return airflow in cfm (L/s).
   k. Outside-air damper position.
   l. Return-air damper position.

G. Apparatus-Coil Test Reports:
1. Coil Data:
   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch (mm) o.c.
   f. Make and model number.
   g. Face area in sq. ft. (sq. m).
   h. Tube size in NPS (DN).
   i. Tube and fin materials.
   j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm (L/s).
   b. Average face velocity in fpm (m/s).
   c. Air pressure drop in inches wg (Pa).
   d. Outside-air, wet- and dry-bulb temperatures in deg F (deg C).
   e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
   f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).

h. Water flow rate in gpm (L/s).

i. Water pressure differential in feet of head or psig (kPa).

j. Entering-water temperature in deg F (deg C).

k. Leaving-water temperature in deg F (deg C).

l. Refrigerant expansion valve and refrigerant types.

m. Refrigerant suction pressure in psig (kPa).

n. Refrigerant suction temperature in deg F (deg C).

o. Inlet steam pressure in psig (kPa).

H. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and unit size.
   e. Manufacturer's serial number.
   f. Fuel type in input data.
   g. Output capacity in Btuh (kW).
   h. Ignition type.
   i. Burner-control types.
   j. Motor horsepower and rpm.
   k. Motor volts, phase, and hertz.
   l. Motor full-load amperage and service factor.
   m. Sheave make, size in inches (mm), and bore.
   n. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

2. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm (L/s).
   b. Entering-air temperature in deg F (deg C).
   c. Leaving-air temperature in deg F (deg C).
   d. Air temperature differential in deg F (deg C).
   e. Entering-air static pressure in inches wg (Pa).
   f. Leaving-air static pressure in inches wg (Pa).
   g. Air static-pressure differential in inches wg (Pa).
   h. Low-fire fuel input in Btuh (kW).
   i. High-fire fuel input in Btuh (kW).
   j. Manifold pressure in psig (kPa).
   k. High-temperature-limit setting in deg F (deg C).
   l. Operating set point in Btuh (kW).
   m. Motor voltage at each connection.
   n. Motor amperage for each phase.
   o. Heating value of fuel in Btuh (kW).

I. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:
   a. System identification.
   b. Location.
   c. Coil identification.
d. Capacity in Btuh (kW).
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Airflow rate in cfm (L/s).
i. Face area in sq. ft. (sq. m).
j. Minimum face velocity in fpm (m/s).

2. Test Data (Indicated and Actual Values):
   a. Heat output in Btuh (kW).
   b. Airflow rate in cfm (L/s).
   c. Air velocity in fpm (m/s).
   d. Entering-air temperature in deg F (deg C).
   e. Leaving-air temperature in deg F (deg C).
   f. Voltage at each connection.
   g. Amperage for each phase.

J. Fan Test Reports: For supply, return, and exhaust fans, include the following:
   1. Fan Data:
      a. System identification.
      b. Location.
      c. Make and type.
      d. Model number and size.
      e. Manufacturer's serial number.
      f. Arrangement and class.
      g. Sheave make, size in inches (mm), and bore.
      h. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

2. Motor Data:
   a. Make and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches (mm), and bore.
   f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
   g. Number of belts, make, and size.

3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm (L/s).
   b. Total system static pressure in inches wg (Pa).
   c. Fan rpm.
   d. Discharge static pressure in inches wg (Pa).
   e. Suction static pressure in inches wg (Pa).

K. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
   1. Report Data:
      a. System and air-handling unit number.
      b. Location and zone.
      c. Traverse air temperature in deg F (deg C).
      d. Duct static pressure in inches wg (Pa).
e. Duct size in inches (mm).

f. Duct area in sq. ft. (sq. m).

g. Indicated airflow rate in cfm (L/s).

h. Indicated velocity in fpm (m/s).

i. Actual airflow rate in cfm (L/s).

j. Actual average velocity in fpm (m/s).

k. Barometric pressure in psig (Pa).

L. Air-Terminal-Device Reports:

1. Unit Data:
   a. System and air-handling unit identification.
   b. Location and zone.
   c. Test apparatus used.
   d. Area served.
   e. Air-terminal-device make.
   f. Air-terminal-device number from system diagram.
   g. Air-terminal-device type and model number.
   h. Air-terminal-device size.
   i. Air-terminal-device effective area in sq. ft. (sq. m).

2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm (L/s).
   b. Air velocity in fpm (m/s).
   c. Preliminary airflow rate as needed in cfm (L/s).
   d. Preliminary velocity as needed in fpm (m/s).
   e. Final airflow rate in cfm (L/s).
   f. Final velocity in fpm (m/s).
   g. Space temperature in deg F (deg C).

M. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:
   a. System and air-handling unit identification.
   b. Location and zone.
   c. Room or riser served.
   d. Coil make and size.
   e. Flowmeter type.

2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm (L/s).
   b. Entering-water temperature in deg F (deg C).
   c. Leaving-water temperature in deg F (deg C).
   d. Water pressure drop in feet of head or psig (kPa).
   e. Entering-air temperature in deg F (deg C).
   f. Leaving-air temperature in deg F (deg C).

N. Packaged Chiller Reports:

1. Unit Data:
   a. Unit identification.
   b. Make and model number.
   c. Manufacturer's serial number.
2. Water-Cooled Condenser Test Data (Indicated and Actual Values):
   a. Refrigerant pressure in psig (kPa).
   b. Refrigerant temperature in deg F (deg C).
   c. Entering-water temperature in deg F (deg C).
   d. Leaving-water temperature in deg F (deg C).
   e. Entering-water pressure in feet of head or psig (kPa).
   f. Water pressure differential in feet of head or psig (kPa).

3. Air-Cooled Condenser Test Data (Indicated and Actual Values):
   a. Refrigerant pressure in psig (kPa).
   b. Refrigerant temperature in deg F (deg C).
   c. Entering- and leaving-air temperature in deg F (deg C).

4. Evaporator Test Reports (Indicated and Actual Values):
   a. Refrigerant pressure in psig (kPa).
   b. Refrigerant temperature in deg F (deg C).
   c. Entering-water temperature in deg F (deg C).
   d. Leaving-water temperature in deg F (deg C).
   e. Entering-water pressure in feet of head or psig (kPa).
   f. Water pressure differential in feet of head or psig (kPa).

5. Compressor Test Data (Indicated and Actual Values):
   a. Suction pressure in psig (kPa).
   b. Suction temperature in deg F (deg C).
   c. Discharge pressure in psig (kPa).
   d. Discharge temperature in deg F (deg C).
   e. Oil pressure in psig (kPa).
   f. Oil temperature in deg F (deg C).
   g. Voltage at each connection.
   h. Amperage for each phase.
   i. Kilowatt input.
   j. Crankcase heater kilowatt.
   k. Chilled-water control set point in deg F (deg C).
   l. Condenser-water control set point in deg F (deg C).
   m. Refrigerant low-pressure-cutoff set point in psig (kPa).
   n. Refrigerant high-pressure-cutoff set point in psig (kPa).

6. Refrigerant Test Data (Indicated and Actual Values):
   a. Oil level.
   b. Refrigerant level.
   c. Relief valve setting in psig (kPa).
   d. Unloader set points in psig (kPa).
   e. Percentage of cylinders unloaded.
   f. Bearing temperatures in deg F (deg C).
   g. Vane position.
   h. Low-temperature-cutoff set point in deg F (deg C).
O. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, or water-cooled condensing units, include the following:

1. Unit Data:
   a. Unit identification.
   b. Location.
   c. Unit make and model number.
   d. Compressor make.
   e. Compressor model and serial numbers.
   f. Refrigerant weight in lb (kg).
   g. Low ambient temperature cutoff in deg F (deg C).

2. Test Data (Indicated and Actual Values):
   a. Inlet-duct static pressure in inches wg (Pa).
   b. Outlet-duct static pressure in inches wg (Pa).
   c. Entering-air, dry-bulb temperature in deg F (deg C).
   d. Leaving-air, dry-bulb temperature in deg F (deg C).
   e. Condenser entering-water temperature in deg F (deg C).
   f. Condenser leaving-water temperature in deg F (deg C).
   g. Condenser-water temperature differential in deg F (deg C).
   h. Condenser entering-water pressure in feet of head or psig (kPa).
   i. Condenser leaving-water pressure in feet of head or psig (kPa).
   j. Condenser-water pressure differential in feet of head or psig (kPa).
   k. Control settings.
   l. Unloader set points.
   m. Low-pressure-cutout set point in psig (kPa).
   n. High-pressure-cutout set point in psig (kPa).
   o. Suction pressure in psig (kPa).
   p. Suction temperature in deg F (deg C).
   q. Condenser refrigerant pressure in psig (kPa).
   r. Condenser refrigerant temperature in deg F (deg C).
   s. Oil pressure in psig (kPa).
   t. Oil temperature in deg F (deg C).
   u. Voltage at each connection.
   v. Amperage for each phase.
   w. Kilowatt input.
   x. Crankcase heater kilowatt.
   y. Number of fans.
   z. Condenser fan rpm.
   aa. Condenser fan airflow rate in cfm (L/s).
   bb. Condenser fan motor make, frame size, rpm, and horsepower.
   cc. Condenser fan motor voltage at each connection.
   dd. Condenser fan motor amperage for each phase.

P. Cooling Tower or Condenser Test Reports: For cooling towers or condensers, include the following:

1. Unit Data:
   a. Unit identification.
   b. Make and type.
   c. Model and serial numbers.
d. Nominal cooling capacity in tons (kW).

e. Refrigerant type and weight in lb (kg).

f. Water-treatment chemical feeder and chemical.

g. Number and type of fans.

h. Fan motor make, frame size, rpm, and horsepower.

i. Fan motor voltage at each connection.

j. Sheave make, size in inches (mm), and bore.

k. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

l. Number of belts, make, and size.

m. Pump make and model number.

n. Pump manufacturer's serial number.

o. Pump motor make and frame size.

p. Pump motor horsepower and rpm.

2. Pump Test Data (Indicated and Actual Values):

   a. Voltage at each connection.

   b. Amperage for each phase.

   c. Water flow rate in gpm (L/s).

3. Water Test Data (Indicated and Actual Values):

   a. Entering-water temperature in deg F (deg C).

   b. Leaving-water temperature in deg F (deg C).

   c. Water temperature differential in deg F (deg C).

   d. Entering-water pressure in feet of head or psig (kPa).

   e. Leaving-water pressure in feet of head or psig (kPa).

   f. Water pressure differential in feet of head or psig (kPa).

   g. Water flow rate in gpm (L/s).

   h. Bleed water flow rate in gpm (L/s).

4. Air Data (Indicated and Actual Values):

   a. Duct airflow rate in cfm (L/s).

   b. Inlet-duct static pressure in inches wg (Pa).

   c. Outlet-duct static pressure in inches wg (Pa).

   d. Average entering-air, wet-bulb temperature in deg F (deg C).

   e. Average leaving-air, wet-bulb temperature in deg F (deg C).

   f. Ambient wet-bulb temperature in deg F (deg C).

Q. Heat-Exchanger/Converter Test Reports: For steam and hot-water heat exchangers, include the following:

1. Unit Data:

   a. Unit identification.

   b. Location.

   c. Service.

   d. Make and type.

   e. Model and serial numbers.

   f. Ratings.

2. Steam Test Data (Indicated and Actual Values):

   a. Inlet pressure in psig (kPa).

   b. Condensate flow rate in lb/h (kW).
3. Primary Water Test Data (Indicated and Actual Values):
   a. Entering-water temperature in deg F (deg C).
   b. Leaving-water temperature in deg F (deg C).
   c. Entering-water pressure in feet of head or psig (kPa).
   d. Water pressure differential in feet of head or psig (kPa).
   e. Water flow rate in gpm (L/s).

4. Secondary Water Test Data (Indicated and Actual Values):
   a. Entering-water temperature in deg F (deg C).
   b. Leaving-water temperature in deg F (deg C).
   c. Entering-water pressure in feet of head or psig (kPa).
   d. Water pressure differential in feet of head or psig (kPa).
   e. Water flow rate in gpm (L/s).

R. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:
   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and size.
   e. Model and serial numbers.
   f. Water flow rate in gpm (L/s).
   g. Water pressure differential in feet of head or psig (kPa).
   h. Required net positive suction head in feet of head or psig (kPa).
   i. Pump rpm.
   j. Impeller diameter in inches (mm).
   k. Motor make and frame size.
   l. Motor horsepower and rpm.
   m. Voltage at each connection.
   n. Amperage for each phase.
   o. Full-load amperage and service factor.
   p. Seal type.

2. Test Data (Indicated and Actual Values):
   a. Static head in feet of head or psig (kPa).
   b. Pump shutoff pressure in feet of head or psig (kPa).
   c. Actual impeller size in inches (mm).
   d. Full-open flow rate in gpm (L/s).
   e. Full-open pressure in feet of head or psig (kPa).
   f. Final discharge pressure in feet of head or psig (kPa).
   g. Final suction pressure in feet of head or psig (kPa).
   h. Final total pressure in feet of head or psig (kPa).
   i. Final water flow rate in gpm (L/s).
   j. Voltage at each connection.
   k. Amperage for each phase.

S. Boiler Test Reports:

1. Unit Data:
   a. Unit identification.
b. Location.
c. Service.
d. Make and type.
e. Model and serial numbers.
f. Fuel type and input in Btuh (kW).
g. Number of passes.
h. Ignition type.
i. Burner-control types.
j. Voltage at each connection.
k. Amperage for each phase.

2. Test Data (Indicated and Actual Values):
   a. Operating pressure in psig (kPa).
   b. Operating temperature in deg F (deg C).
   c. Entering-water temperature in deg F (deg C).
   d. Leaving-water temperature in deg F (deg C).
   e. Number of safety valves and sizes in NPS (DN).
   f. Safety valve settings in psig (kPa).
   g. High-limit setting in psig (kPa).
   h. Operating-control setting.
   i. High-fire set point.
   j. Low-fire set point.
   k. Voltage at each connection.
   l. Amperage for each phase.
   m. Draft fan voltage at each connection.
   n. Draft fan amperage for each phase.
   o. Manifold pressure in psig (kPa).

T. Air-to-Air Heat-Recovery Unit Reports:
   1. Unit Data:
      a. Unit identification.
      b. Location.
      c. Service.
      d. Make and type.
      e. Model and serial numbers.

   2. Motor Data:
      a. Make and frame type and size.
      b. Horsepower and rpm.
      c. Volts, phase, and hertz.
      d. Full load amperage and service factor.
      e. Sheave make, size in inches (mm), and bore.
      f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

   3. If fans are an integral part of the unit, include the following for each fan:
      a. Make and type.
      b. Arrangement and size.
      c. Sheave make, size in inches (mm), and bore.
      d. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
4. Test Data (Indicated and Actual Values):
   a. Total exhaust airflow rate in cfm (L/s).
   b. Purge exhaust airflow rate in cfm (L/s).
   c. Outside airflow rate in cfm (L/s).
   d. Total exhaust fan static pressure in inches wg (Pa).
   e. Total outside-air fan static pressure in inches wg (Pa).
   f. Pressure drop on each side of recovery wheel in inches wg (Pa).
   g. Exhaust air temperature entering in deg F (deg C).
   h. Exhaust air temperature leaving in deg F (deg C).
   i. Outside-air temperature entering in deg F (deg C).
   j. Outside-air temperature leaving in deg F (deg C).
   k. Calculate sensible and total heat capacity of each airstream in MBh (kW).

U. Vibration Measurement Reports:
   1. Date and time of test.
   2. Vibration meter manufacturer, model number, and serial number.
   3. Equipment designation, location, equipment, speed, motor speed, and motor horsepower.
   4. Diagram of equipment showing the vibration measurement locations.
   5. Measurement readings for each measurement location.
   7. Description of predominant vibration source.

V. Sound Measurement Reports: Record sound measurements on octave band and dBA test forms and on an NC or RC chart indicating the decibel level measured in each frequency band for both "background" and "HVAC system operating" readings. Record each tested location on a separate NC or RC chart. Record the following on the forms:
   1. Date and time of test. Record each tested location on its own NC curve.
   2. Sound meter manufacturer, model number, and serial number.
   3. Space location within the building including floor level and room number.
   4. Diagram or color photograph of the space showing the measurement location.
   5. Time weighting of measurements, either fast or slow.
   6. Description of the measured sound: steady, transient, or tonal.
   7. Description of predominant sound source.

W. Indoor-Air Quality Measurement Reports for Each HVAC System:
   1. HVAC system designation.
   2. Date and time of test.
   3. Outdoor temperature, relative humidity, wind speed, and wind direction at start of test.
   4. Room number or similar description for each location.
   5. Measurements at each location.
   6. Observed deficiencies.

X. Instrument Calibration Reports:
   1. Report Data:
      a. Instrument type and make.
      b. Serial number.
      c. Application.
      d. Dates of use.
      e. Dates of calibration.
3.34 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.

2. Randomly check the following for each system:
   a. Measure airflow of at least 10 percent of air outlets.
   b. Measure water flow of at least 5 percent of terminals.
   c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
   d. Measure sound levels at two locations.
   e. Measure space pressure of at least 10 percent of locations.
   f. Verify that balancing devices are marked with final balance position.
   g. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner.

2. TAB firm test and balance engineer shall conduct the inspection in the presence of Owner.

3. Owner shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.

4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.

7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.35 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 230593
SECTION 230700 – HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Extent of mechanical insulation required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of mechanical insulation specified in this section include the following:

1. Piping System Insulation:
   a. Fiberglass.
   b. Cellular Glass.
   c. Calcium Silicate.
   d. Flexible Unicellular.

2. Ductwork System Insulation:
   a. Fiberglass.
   b. Fire-Rated Duct Insulation.

3. Equipment Insulation:
   a. Fiberglass.
   b. Calcium Silicate.
   c. Flexible Unicellular.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS

A. Refer to Division 23 Section "Basic Mechanical Requirements."

B. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, certifications, k-value, thickness, and furnished accessories for each mechanical system requiring insulation.

1.4 QUALITY ASSURANCE

A. Installer's Qualifications: Firm with at least five (5) years successful installation experience on projects with mechanical insulations similar to that required for this project.

B. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastic and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

1.5 GREENGUARD CERTIFICATION: PROVIDE FIBERGLAS INSULATION PRODUCTS THAT ARE GREENGUARD CERTIFIED.DELIVERY, STORAGE, AND HANDLING

A. Refer to Division 23 Section "Basic Mechanical Requirements."
B. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.

C. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products of one of the following:

1. ArmaCell.
2. CertainTeed.
3. Knauf Fiber Glass GmbH.
5. Manson.
6. Owens-Corning Fiberglass Corp.
7. Armaflex.

2.2 PIPING INSULATION MATERIALS

A. Fiberglass Piping Insulation: ASTM C 547, Class 1 unless otherwise indicated, K = .23 at 75 deg. F.

B. Calcium Silicate Piping Insulation: ASTM C 533, Type I.

C. Cellular Glass Piping Insulation: ASTM C 552, Type II, Class 2.

D. Flexible Unicellular Piping Insulation: ASTM C 534, Type I.

1. Basis of Design: AP Armaflex FS.

E. Jackets for Piping Insulation: ASTM C 1136, Type I for piping with temperatures below ambient, Type II for piping with temperatures above ambient. Type I may be used for all piping at Installers option.

1. Encase fiberglass and calcium silicate pipe fittings insulation with one-piece premolded PVC fitting covers, fastened as per manufacturer's recommendations.
2. Encase all exposed pipe insulation in occupied rooms with PVC pipe covers.
   a. Thickness shall be 30 mil from floor level to 9 feet above finished floor. Otherwise, thickness shall be 20 mil.
3. Bond all PVC seams in occupied rooms with polyco VP adhesive, or equal. Bond adhesive shall conform to ASTM D-2654.
4. Encase exterior piping insulation with aluminum jacket with weatherproof construction.
   a. .016 inch thick smooth aluminum with polysurlyn moisture retarder.
5. Encase piping insulation installed in interstitial areas installed at 3'-0" or less above the finished floor level with 0.016 inch thick smooth aluminum jacket attached with bands. Staples, Bands, Wires, and Cement: As recommended by insulation manufacturer for applications indicated.
F. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

G. Removable/Reusable Insulation Valve Covers: Two piece, silicone impregnated finish, Type E glass fiber insulation. Shannon Enterprises of W.N.Y., Inc. – Insultech, or approved equal.

2.3 DUCTWORK INSULATION MATERIALS

A. Rigid Fiberglass Ductwork Insulation: ASTM C 612, Class 1, minimum 3.0 LBS/FT3.

B. Flexible Fiberglass Ductwork Insulation: ASTM C 553, Type I, Class B-4, minimum 0.75 LBS/FT3.

C. Fire Rated Ductwork Insulation. Blanket shall be manufactured from calcia, magnesia, silica chemistry designed to enhance biosolubility, 8 lb/cubic feet, ASTM E84 with flame spread less than 25 and smoke developed rating less than 50.
   1. Unifrax FyreWrap EZ 1.5, Firemaster Fastwrap XL, or approved equal for non-grease ducts.
   2. Unifrax FyreWrap MAX 2.0, Firemaster Fastwrap XL, or approved equal for grease ducts. Provide ASTM E-2336 compliant system.

D. Jackets for Ductwork Insulation: Foil-Skrim-Kraft (FSK) ASTM C 1136, Type I for ductwork with temperatures below ambient; Type II for ductwork with temperatures above ambient.

E. Ductwork Insulation Accessories: Provide staples, bands, tape, anchors, corner angles, glues, and similar accessories as recommended by insulation manufacturer for applications indicated.

F. Ductwork Insulation Compounds: Provide cements, adhesives, coatings, sealers, protective finishes, and similar compounds as recommended by insulation manufacturer for applications indicated.

2.4 EQUIPMENT INSULATION MATERIALS

A. Rigid Fiberglass Equipment Insulation: ASTM C 612, Class 2, minimum 3.0 LBS/FT3.

B. Flexible Fiberglass Equipment Insulation: ASTM C 553, Type II, Class F-1, minimum 2.5 LBS/FT3.

C. Calcium Silicate Equipment Insulation: ASTM C 533, Type I, Block.

D. Flexible Unicellular Equipment Insulation: ASTM C 534, Type II.

E. Jacketing Material for Equipment Insulation: Provide pre-sized glass cloth jacketing material, not less than 7.8 ounces per square yard, or aluminum jacket at installer's option, except as otherwise indicated.

F. Equipment Insulation Compounds: Provide adhesives, cements, sealers, mastic, and protective finishes as recommended by insulation manufacturer for applications indicated.

G. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape, corner angles, anchors, and stud pins as recommended by insulation manufacturer for applications indicated.
PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 HVAC PIPING SYSTEM INSULATION

A. Insulation Omitted: Omit insulation on hot piping within radiation enclosures or unit cabinets; on cold piping within unit cabinets provided piping is located over drain pan; on unions, flexible connections, and expansion joints.

B. Cold Piping (below 40 deg. F) Application Requirements: Insulate the following sub-freezing HVAC piping systems:

1. Refrigerant suction lines between evaporators and compressors. Brine refrigerant piping.
   a. Insulate both refrigerant suction and liquid lines as a unit where recommended by manufacturer.

2. Computer Room glycol cooling supply and return piping.

3. Insulate each piping system specified above with one of the following types and thicknesses of insulation:
   a. Fiberglass: 1-1/2 inch thick for pipe sizes up to and including 1 inch; 2 inch thick for pipe sizes over 1 inch.
   b. Cellular Glass: 1-1/2 inch thick for pipe sizes up to and including 1 inch; 2 inch thick for pipe sizes over 1 inch.
   c. Flexible Unicellular: 1-1/2 inch thick for all pipe.

C. Cold Piping (40 deg. F to ambient) Application Requirements: Insulate the following cold HVAC piping systems:

1. HVAC chilled water supply and return piping.

2. HVAC make-up water piping.

3. Air conditioner condensate drain piping.

4. Chemical feed piping.

5. Insulate each piping system specified above with one of the following types and thicknesses of insulation:
   a. Fiberglass: 1-1/2 inch thick for pipe sizes up to 1 inch; 2 inch for pipe sizes 1-1/4 inch and larger.
   b. Cellular Glass: 1-1/2 inch thick for pipe sizes up to 1 inch; 2 inch for pipe sizes 1-1/4 inch and larger.

D. Hot Low Pressure Piping (to 200 deg. F) Above Ground Application Requirements: Insulate the following hot low pressure HVAC piping systems (water piping up to 200 deg. F):

1. HVAC hot water (glycol) supply and return piping.

2. Dual temperature (glycol) supply and return piping.

3. Condensate and pumped condensate piping.

4. Low pressure boiler feed water piping.

5. Heated fuel piping.
6. Hot gas refrigerant piping.
7. Insulate each piping system specified above with one of the following types and thicknesses of insulation:
   a. Fiberglass:
      1) Hot Water: 1-1/2 inch thick for pipe sizes up to and including 1-1/4 inch, 2 inch thick for pipe 1-1/2 inch and larger.
      2) Calcium Silicate: 3 inch thick for boiler headers.

E. Hot Low Pressure Piping (201 deg. F to 250 deg. F) Above Ground Application Requirements:
   Insulate the following hot low pressure HVAC piping systems (steam piping up to 15 psi, water piping 201 deg. F to 250 deg. F):
   1. HVAC hot water (glycol) supply and return piping.
   2. Dual temperature (glycol) supply and return piping.
   3. Low pressure steam, condensate, and pumped condensate piping.
   4. Insulate each piping system specified above with one of the following types and thicknesses of insulation:
      a. Fiberglass: 2-1/2 inch thick for pipe sizes up to 3 inch; 3 inch thick for pipe sizes 4 inch and larger.

F. Hot Medium Pressure Piping (251 deg. F to 350 deg. F) Above Ground Application Requirements: 
   Insulate the following hot medium pressure HVAC piping systems (steam piping from 16 to 85 psi, water piping 251 deg. F to 350 deg. F):
   1. HVAC hot water (glycol) supply and return piping.
   2. Medium pressure steam and condensate piping.
   3. Insulate each piping system specified above with one of the following types and thicknesses of insulation:
      a. Fiberglass: 4 inch thick for pipe sizes up to 1-1/4 inch; 5 inch thick for pipe sizes 1-1/2 inch and larger.
      b. Calcium Silicate: 5 inch thick for boiler headers.

G. Hot High Pressure Piping (351 deg. F to 450 deg. F) Above Ground Application Requirements:
   Insulate the following hot high pressure HVAC piping systems (steam piping from 86 to 200 psi, water piping 351 deg. F to 450 deg. F):
   1. High temperature hot water supply and return piping.
   2. High pressure steam and condensate piping.
   3. High pressure boiler feed water piping and blowdown piping.
   4. Insulate each piping system specified above with one of the following types and thicknesses of insulation:
      a. Fiberglass: 5 inch thick for all pipe sizes.
      b. Calcium Silicate: 5 inch thick for boiler headers.

H. Hot Low Pressure Piping (to 250 deg. F) Underground Application Requirements: 
   Insulate the following hot low pressure HVAC piping systems (steam piping up to 15 psi, water piping up to 250 deg. F):
   1. HVAC hot water supply and return piping.
   2. Low pressure steam, condensate and pumped condensate piping.
3. Heated fuel piping.

4. Insulate each piping system specified above with the following type and thickness of insulation:
   a. Cellular Glass: 3 inch thickness with finish cover of "Pittwrap" jacketing.

I. Hot, Medium, and High Pressure Piping (up to 450 deg. F) Underground Application Requirements: Insulate the following hot, medium, and high pressure HVAC piping systems (steam piping from 16 to 200 psi, water piping 251 deg. F to 450 deg. F):
   1. High temperature hot water supply and return piping.
   2. High pressure steam and condensate piping.
   3. Insulate each piping system specified above with one of the following types and thicknesses of insulation:
      a. Cellular Glass: 5 inch thick for all pipe sizes. Finish cover of "Pittwrap" jacketing.

J. Hot and Cold Pressure Outdoor Piping (to 250 deg. F) Application Requirements: Insulate the following hot and cold low pressure HVAC piping systems:
   1. Hot water (glycol) supply and return piping.
   2. Chilled water supply and return piping.
   3. Condenser water supply and return piping.
   4. Insulate each piping system specified above with the following type and thickness of insulation:
      a. Cellular Glass: 3 inch thickness with "Pittcote 300" coating and outdoor insulation finish.

K. All insulation thicknesses defined above are minimum requirements and shall be increased as required to comply with requirements of SPS 363 Energy Conservation.

3.3 DUCTWORK SYSTEM INSULATION

A. Insulation Omitted: Do not insulate double-wall insulated ductwork.

B. Ductwork Application Requirements: Insulate the following ductwork:
   1. Outdoor air intake ductwork between air entrance and fan inlet or HVAC unit inlet.
   2. HVAC supply ductwork between fan discharge, or HVAC unit discharge, and room terminal outlet.
   3. HVAC return ductwork in mechanical equipment rooms, installed outdoors or unconditioned spaces.
   4. HVAC plenums and unit housings not pre-insulated at factory.
   5. Emergency generator exhaust plenums.
   6. Exhaust fan and gravity relief plenums and ductwork 10 feet in all directions from exterior wall and roof penetrations.
   7. Insulate each ductwork system specified above with one of the following types and thicknesses of insulation:
      a. Rigid Fiberglass: 2 inch thick for indoor exposed ductwork; 3 inch thick for exterior ductwork.
      b. Flexible Fiberglass: 2 inch thick, application limited to indoor concealed locations.

C. Ductwork penetrating 2-hour fire separation; provide fire rated insulation where indicated and as required to maintain fire rating integrity.
D. Provide mechanical fasteners 12 inches o.c. for ducts 24 inches and over. Do not compress insulation with washer.

E. All insulation thicknesses defined above are minimum requirements and shall be increased as required to comply with requirements of SPS 363 Energy Conservation.

3.4 EQUIPMENT INSULATION

A. Cold Equipment (Below Ambient Temperature) Application Requirements: Insulate the following cold equipment:
   1. Refrigeration equipment, including chillers, tanks, and pumps.
   2. Drip pans under chilled equipment.
   3. Cold and chilled water pumps.
   4. Aftercoolers.
   5. Air separators.
   8. Insulate each item of equipment specified above with one of the following types and thicknesses of insulation:
      a. Fiberglass: 1 inch thick for surfaces above 40 deg. F (2 deg. C); 1-1/2 inch thick for surfaces 40 deg. F (2 deg. C) and lower.
      b. Flexible Unicellular: 1-1/2 inch thick.

B. Hot Equipment (Above Ambient Temperature) Application Requirements: Insulate the following hot equipment:
   1. Boilers (not pre-insulated at factory).
   2. Boiler deaerator and surge tanks, and blowdown separators.
   3. Hot water storage tanks (not pre-insulated at factory).
   4. Water heaters (not pre-insulated at factory).
   5. Heat exchangers.
   6. Condensate receivers.
   7. Fuel oil heaters.
   8. Flash tanks.
   10. Insulate each item of equipment specified above with one of the following types and thicknesses of insulation:
        a. Fiberglass: 2 inch thick.
        b. Calcium Silicate: 3 inch thick.

11. Breeching and Stacks Application Requirements: Insulate the following breechings and stacks:
    a. Breechings between heating equipment outlet and stack or chimney connection, except for double wall or factory insulated breechings.
    b. Stacks from bottom to top except for factory insulated stacks.
    c. Insulate each breeching and stack specified above with the following thicknesses of insulation:
       1) Calcium Silicate: 3 inch thick.
C. Emergency Generator Exhaust Systems Application Requirements: Insulate the following emergency generator exhaust systems:
   1. Exhaust pipes between engine and muffler and muffler to discharge and muffler which are not exposed to weather.
   2. Insulate each emergency generator exhaust system specified above with the following type and thickness of insulation.
      a. Calcium Silicate: 3 inch thick.

3.5 INSTALLATION OF PIPING INSULATION
   A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.
   B. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.
   C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other.
   D. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
   E. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.
   F. Cover valves, fittings, air separators and all other piping system components in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at installer's option) except where specific form or type is indicated.
   G. Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise indicated.
   H. Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply 3 inch wide vapor barrier tape or band over the butt joints. For cold piping, apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3 inch wide vapor barrier tape or band.
   I. Provide removable valve covers for valves which must be accessed periodically.

3.6 INSTALLATION OF DUCTWORK INSULATION
   A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.
   B. Install insulation materials with smooth and even surfaces.
   C. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
   D. Maintain integrity of vapor barrier on ductwork insulation, and protect it to prevent puncture and other damage.
E. Extend ductwork insulation without interruption through walls, floors, and similar ductwork penetrations, except where otherwise indicated.

F. Corner Angles: Install corner angles on external corners of insulation on ductwork in exposed finished spaces before covering with jacketing.

G. Fire Rated Duct Insulation: Install per manufacturer's instructions to obtain 2-hour fire resistance rating and associated ASTM/UL rating.

3.7 INSTALLATION OF EQUIPMENT INSULATION

A. General: Install equipment thermal insulation products in accordance with manufacturer's written instructions, and in compliance with recognized industry practices to ensure that insulation serves intended purpose.

B. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gaping joints and excessive voids resulting from poor workmanship.

C. Maintain integrity of vapor barrier on equipment insulation and protect it to prevent puncture and other damage.

D. Do not apply insulation to equipment, breechings, or stacks while hot.

E. Apply insulation using staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.

F. Coat insulated surfaces with layer of insulating cement, trowled in workmanlike manner, leaving smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.

G. Cover insulated surfaces with all-service jacketing neatly fitted and firmly secured. Lap seams at least 2 inches. Apply over vapor barrier where applicable.

H. Do not insulate boiler manholes, handholes, cleanouts, ASME stamp, and manufacturer's nameplate. Provide neatly beveled edge at interruptions of insulation.

I. Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames, accessories, and pumps. Removable sections shall be secured with release latches or hook & loop fasteners sized for the applicable load.

3.8 OUTDOOR INSULATION FINISH

A. General: Piping, ductwork and equipment exposed to weather shall have insulation protective finish or jacketing installed as recommended by manufacturer.

B. Piping: Shall have aluminum jacket with moisture barrier with locking longitudinal seam and butt straps. Fittings, valves, flanges, etc. shall have factory or job fabricated aluminum cover secured with banding and/or screws.

C. Piping: Shall have a 0.020 inch minimum thickness PVC jacket with moisture barrier with locking longitudinal seam and butt straps. Fittings, valves, flanges, etc., shall have factory or job fabricated PVC cover secured with banking and/or screws.

D. Round Ductwork: Same finish as piping.
E. Rectangular Ductwork and Equipment: Shall have a laminated jacketed system Alumaguard 60 by Polyguard Products, Inc., or approved equal. The laminated jacketing system shall be 60 mil thick, and shall consist of a rubberized bitumen compound, heat applied to a cross-laminated high strength polyethylene film, laminated to aluminum foil.

F. Install exterior aluminum pipe jacket with laps pointing down on horizontal piping. Caulk all joints and laps with aluminum colored silicone caulk.

3.9 EXISTING INSULATION REPAIR
A. Repair damaged sections of existing mechanical insulation damaged during this construction period. Use insulation of same thickness as existing insulation, install new jacket lapping and seal over existing.

3.10 PROTECTION AND REPLACEMENT
A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. Protection: Insulation installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION 230700
SECTION 230800 – COMMISSIONING of HVAC

PART 1 - GENERAL

1.1 SCOPE

A. The purpose of this section is to specify the Division 23 responsibilities and participation in the commissioning process.

B. Work under this contract shall conform to requirements of Division 01, General Requirements, Conditions of the Contract and Supplementary Conditions. This specification covers commissioning of HVAC systems which are part of this project.

C. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.

1.2 REFERENCE

A. Applicable provisions of Division 1 govern work under this section.

B. Specific performance requirements are given in the following sections of these specifications:
   1. Division 01 Section "Project Management and Coordination"
   2. Division 01 Section "Submittal Procedures"
   3. Division 01 Section "Sustainability Certification Project Requirements"
   4. Division 01 Section "Starting andAdjusting"
   5. Division 01 Section "Closeout Procedures"
   6. Division 01 Section "Closeout Submittals"
   7. Division 01 Section "Demonstration and Training"
   8. Division 01 Section "General Commissioning Requirements"
   9. Division 20 Section "Functional Performance Testing Common Work Results, Division 21 – 28"
   10. Division 23 Section "Basic Mechanical Requirements"* 
   11. Division 23 Section "Basic Mechanical Materials and Methods"
   12. Division 23 Section "Testing, Adjusting, and Balancing for HVAC"
   13. Division 23 Section "Commissioning of HVAC"
   14. Division 23 Section "Instrumentation and Control for HVAC"

C. Sustainable Design Intent: Comply with project requirements to meet the applicable commissioning prerequisites and credits pursued for the Sustainability/Sustainable Green Building Rating System, of the US Green Building Council.

1.3 DEFINITIONS

A. Commissioning (Cx): The process of ensuring that systems are designed, installed, functionally tested and performing in conformity with Owners Project Requirements (OPR) the design intent (Basis of Design BoD)) and that the building operator has received complete equipment and systems documentation and training.

B. Commissioning Provider (CxP): The entity identified to lead, monitor, coordinate and report on project commissioning activities.

C. Commissioning Plan: A detailed plan of the organization, schedule, allocation of resources, procedures and documentation requirements of the commissioning process.
D. Construction Verification (CV): A quality control verification process performed by the installer as building assemblies, components, equipment and systems are being installed which documents that the materials, installation procedures, interfaces with other trades, start-up, testing and operation are correct, complete and in compliance with contract documents and manufacturer’s recommendations and are ready for functional performance testing.

E. Functional Performance Tests (FPT): Contractor testing of installed building assemblies, components, equipment, systems and interfaces which confirms correct performance through all operating modes and compliance with contract documents and manufacturer’s recommendations.

F. Commissioning Report: A document that records the activities and results of the commissioning process.

1.4 COORDINATION

A. Commissioning Team: The members of the commissioning team consist of the Commissioning Provider (CxP), the Owner’s Project Manager (OPM), the Construction Manager or General Contractor (CM or GC), the design Architect and Engineers (A/E), the Mechanical Contractor (MC), the Electrical Contractor (EC), the Testing, Adjusting, and Balancing contractor (TAB), the Controls Contractor (CC), the Communications and Technology Contractor (CTC), the Owner’s maintenance staff, and any other installing subcontractors or suppliers of equipment.

B. Management: The general contractor that is awarded the project shall not include the cost of the Commissioning Provider in their price. The general contractor (and their sub-contractors) shall include cost for their involvement in the commissioning process as described in this section and other related commissioning sections, including completion of construction verification checklists, demonstration of installed equipment to the commissioning team members during the functional performance testing portion of the project.

C. Scheduling: The CM/GC shall integrate all commissioning activities into the master construction schedule. A timeline determined by the commissioning agent will be dedicated for system commissioning. The MEP Contractors shall coordinate their commissioning schedule needs with CM prior to the start of construction to ensure inclusion into the overall construction schedule. The CxP will work with the OPM and CM/GC to schedule commissioning activities. All parties will address scheduling issues in a timely manner in order to expedite the commissioning process.

D. Tracking Contractor Required Testing: Each contractor is responsible for completing various tests per their associated specifications. Each contractor will forward a list of their associated tests to the CxP, who will generate an overall list for tracking purposes.

1.5 COMMISSIONING PROCESS

A. The following activities describe the commissioning tasks and the general order in which they occur. The CxP coordinates all activities.

1. Scoping Meeting: All members of the design and construction team that will be involved in the commissioning process meet and agree on the scope of work, tasks, schedules, deliverables, and responsibilities for implementation of the Commissioning Plan.

2. Commissioning Plan: The Commissioning Plan developed by the CxP provides guidance in the execution of the commissioning process. The Specifications take precedence over the Commissioning Plan.
3. Submittals: Contractor submittals, including detailed start-up procedures, applicable to systems being commissioned is submitted to the CxP to be reviewed concurrent with the A/E’s review. The CxP will review contractor submittals for compliance with OPR and BoD.

4. Site Visits: Commissioning is a team effort requiring the cooperation of all parties. Contractors are to proactively carry out their commissioning responsibilities and are to assist the CxP during site visits in performing commissioning tasks. This includes providing access to and demonstrating the installation, operation and testing of commissioned systems; responding to CxP requests for information; carrying out proactive and corrective actions; and accurate reporting on system status and conditions.

5. Start-Up/Construction Verification Checklists: The CxP works with the Subcontractors to develop startup plans and documentation formats, including providing the Subcontractors with construction verification checklists to be completed prior to the acceptance testing process.

6. Functional Performance Testing: The CxP develops specific equipment and system functional performance test procedures. The Subcontractors review the procedures. The procedures are executed by the Subcontractors, under the direction of, and documented by the CxP.

7. Deficiencies and Resolution: The CxP documents items of non-compliance in materials, installation or operation in an Issues Log. The items are corrected at the Sub’s expense and the equipment or systems are retested. Each contractor is responsible for completing action items in a timely manner that are noted in the Issues Log as their responsibility. Timely response and successful completion are a requirement to avoid withholding of payment. The CM/GC will be responsible for any cost associated with the CxP for retesting.

8. Operations and Maintenance Documentation: The CxP reviews the Operation and Maintenance documentation provided by the Subcontractors for completeness.

9. Training: The CxP reviews the training provided by the Subcontractors and verifies that it is completed.

10. Seasonal Testing: Deferred or seasonal testing is conducted, as required.

11. Warranty Review: The CxP will review status of warranty and building performance issues with the OPM, A/E, CM/GC roughly 10 months after occupancy.

1.6 RESPONSIBILITIES

A. The responsibilities of various parties in the commissioning process are provided in this section. Note that the services for the Owner’s Project Manager, Design Team, and Commissioning Provider are not included in this contract. The Contractor is not responsible for providing their services. Their responsibilities are listed here to clarify the commissioning process.

B. Commissioning Provider (CxP): The CxP is not responsible for design concept, design criteria, code compliance, general construction scheduling, cost estimating, or construction management. The CxP may assist with problem-solving deficiencies, but ultimately that responsibility resides with the General Contractor and the A/E. The primary role of the CxP is to develop and coordinate the execution of a testing plan to verify and document that systems are functioning in accordance with the design intent and the Construction Documents.

1. Construction and Acceptance Phase:
   a. Coordinates and directs all commissioning activities. Work with the CM/GC and OPM to confirm that commissioning activities are scheduled.
   b. Maintain an up-to-date Commissioning Plan.
   c. Plan and conduct the commissioning scoping meeting.
d. Request and review additional information required to perform commissioning tasks, including Operation and Maintenance materials, contractor start-up and checkout procedures, and sequences of operation.

e. Review Contractor submittals applicable to commissioned systems.

f. Assist Subcontractors with the development of start-up and checkout plans.

g. Write and distribute construction verification checklists to be completed by the responsible Subcontractor.

h. Perform site visits, as necessary, to observe component and system installations. Attend construction job-site meetings, as necessary, to monitor construction and commissioning progress.

i. Review completed construction verification checklist and start-up reports.

j. Assist with coordination of start-up requirements with TAB requirements.

k. Write functional performance test procedures for equipment and systems.

l. Coordinate, witness, and document functional performance tests completed by installing contractors. Coordinate retesting as necessary until satisfactory performance is verified.

m. Maintain a master deficiency and resolution record. Provide the OPM with written progress reports and test results with recommended actions.

n. Review the training proposed by the contractors for the Owner’s operating personnel.

o. Review the Operation and Maintenance manuals.

p. Prepare a final commissioning report.

2. Warranty Period:

a. Coordinate and supervise required seasonal or deferred testing and deficiency corrections.

b. Assist in the development of a preventative maintenance plan and review as-built documentation.

C. Design Team (A/E):

1. Construction and Acceptance Phase:

a. Attend commissioning scoping meeting and additional meetings, as necessary.

b. Provide design intent and sequence of operation documentation as required by the CxP.

c. Assist in resolution of system deficiencies identified during commissioning.

d. Review and approve the operations and maintenance manuals.

2. Warranty Period:

a. Assist in resolution of system deficiencies identified during warranty period commissioning.

b. Attend the end-of-warranty review walkthrough to assist in identifying issues requiring resolution and the action plan to do so.

D. Owner’s Project Manager (OPM):

1. Construction and Acceptance Phase:

a. Manage the contract of the CxP.

b. Attend commissioning scoping meeting and additional meetings, as necessary.

c. Arrange for facility operating and maintenance personnel to participate in commissioning activities and training sessions.

d. Provide final approval for the completion of the commissioning work.
2. Warranty Period:
   a. Ensure that any seasonal or deferred testing and any deficiency issues are addressed.
   b. Attend the end-of-warranty review.

E. General Contractor or Construction Manager (CM or GC):
   1. Construction and Acceptance Phase:
      a. Facilitate the coordination of the commissioning work by the CxP.
      b. Attend commissioning scoping meeting and additional meetings, as necessary.
      c. Furnish copies of construction documents, addenda, change orders and approved submittals and shop drawings related to commissioned equipment to the CxP.
      d. Confirm that Subcontractors execute their quality assurance and commissioning responsibilities according to the Specifications and Commissioning Plan.
      e. Ensure CxP access to observe and witness equipment system installation and operation.
      f. Coordinate the training of Owner personnel, according to the Specifications.
      g. Prepare Operation and Maintenance manuals, according to the Specifications, including updating original sequences of operation to as-built conditions.
      h. Attend regularly scheduled commissioning meetings.
   2. Warranty Period:
      a. Confirm that Subcontractors execute required seasonal or deferred functional performance testing.
      b. Confirm that Subcontractors correct deficiencies and make necessary adjustments to Operation and Maintenance manuals and as-built drawings for issues identified during the warranty period.
      c. Attend the end-of-warranty review.

F. Equipment Suppliers:
   1. Provide requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in effect.
   2. Provide information requested by CxP regarding equipment sequence of operation and testing procedures.
   3. Assist in equipment testing and training per agreements with Subcontractors.

G. Mechanical, Electrical, Plumbing, Controls, TAB and other Sub-Contractors:
   1. Installing subcontractors shall fill out construction verification checklists generated by the CxP.
   2. The sub-contractor responsible for the startup and operational checkout of each commissioned system shall participate in functional performance testing and execute the test plans generated by the CxP.
   3. Attend regularly scheduled commissioning meetings.
   4. Ensure CxP access to observe and witness equipment system installation and operation.
   5. Submit required Contractor quality assurance test reports to Architect and Commissioning Provider for review.
   6. Submit completed start-up reports for commissioned equipment signed by the factory-trained and authorized representatives performing the associated work.
   7. Submit Testing and Balancing plan for review and completed TAB report to Architect and Commissioning Provider for review.
8. Submit completed System Readiness Checklists, with completed startup sheets attached, to Commissioning Provider. System functional performance testing shall not commence until the system is documented as ready for testing.

9. Submit operation and maintenance (O&M) manuals for systems being commissioned to Architect and Commissioning Provider for review

10. Provide training for the Owner’s facility staff for regular operations, maintenance, and troubleshooting

11. Refer to applicable quality assurance and commissioning sections as noted in Section 1.2 for additional responsibilities.

1.7 COMMISSIONING SCOPE

A. The following checked equipment shall be commissioned for this project.

B. Existing downstream devices and terminal units of new primary equipment shall be included in the commissioning scope.

C. FPT sample is 100% unless noted otherwise.

D. Integrated systems interactions between HVAC, Electrical, etc. shall be tested. Reference Division 20 Section “Functional Performance Testing Common Work Results, Division 21 – 28”

<table>
<thead>
<tr>
<th>System</th>
<th>Equipment</th>
<th>FPT Sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division 23</td>
<td>HVAC Systems</td>
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<td></td>
<td>Chillers</td>
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<td>Heating Hot Water and Chilled Water Pumps</td>
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<td>Cooling Tower</td>
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<td>Boilers</td>
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<td>Piping systems</td>
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<td>Heat Exchangers</td>
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<td></td>
<td>Variable Frequency Drives</td>
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<td></td>
<td>Air Handling Units (Energy Recovery where applicable)</td>
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<tr>
<td></td>
<td>Roof Top Units (Energy Recover where applicable)</td>
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<td></td>
<td>Packaged AC units</td>
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<td></td>
<td>Packaged HP units</td>
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<tr>
<td></td>
<td>VAV / CV Terminal Devices</td>
<td>50%</td>
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<tr>
<td></td>
<td>Terminal Devices: Fan Coil Units</td>
<td>50%</td>
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<tr>
<td></td>
<td>Hotel Room Fan Coil Units</td>
<td>50%</td>
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<tr>
<td></td>
<td>Terminal Devices: Cabinet Unit Heaters, Unit Heaters, Finned Tube Radiation</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>Ductwork</td>
<td></td>
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<td></td>
<td>Computer room cooling units</td>
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<td></td>
<td>Kitchen Exhaust and MUA</td>
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<td></td>
<td>Fume Hoods</td>
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<td></td>
<td>Lab Room Pressures</td>
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<td></td>
<td>Exhaust Fans</td>
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<td></td>
<td>Chemical Treatment Systems</td>
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<td></td>
<td>Control Dampers</td>
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<tr>
<td></td>
<td>Stairwell Pressurization</td>
<td></td>
</tr>
</tbody>
</table>
PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested. Equipment to be calibrated within the past year and in accordance with the manufacturer’s recommendations.

B. Contractors to provide the electronic means (equipment) required to enter construction verification data from on site if the Commissioning Provider utilizes a web-based program.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed.

D. All testing equipment shall be of sufficient quality and accuracy to test or measure system performance as required by the specifications.

E. Datalogging equipment or software required to test equipment provided by the CxP shall not become the property of the CM/GC or Owner.

PART 3 - EXECUTION

3.1 MEETINGS

A. Pre-Construction Scoping Meeting: The CxP will schedule, plan and conduct a pre-construction scoping meeting with the entire commissioning team in attendance. The CM/GC will ensure all relevant Subcontractors attend. The CxP will present an overview of the project’s commissioning process and the commissioning team members will be identified and their responsibilities reviewed.

B. Miscellaneous Meetings: Other meetings will be planned and conducted by the CxP as construction progresses. Each contractor is required to attend all meetings related to commissioning (pre-construction, construction progress, commissioning meetings, etc.) and to have personnel requested by CxP in attendance to facilitate quality control and coordinate commissioning efforts. Contractors are to provide a review of project progress, a report on the status of issues, commissioning tasks and scheduling for future commissioning tasks.

C. Warranty Review Meeting: Within 10 months of substantial completion and prior to completion of the warranty period, CxP will coordinate and facilitate a review meeting. The intent of the meeting will be to review the project design, construction, turnover, operation and warranty issues. Contractor is required to have key project personnel in attendance and participating in the review for the purposes of making future project delivery improvements.

D. The CxP will distribute meeting minutes to all parties.
3.2 REPORTING

A. The CM/GC shall include the CxP on all OAC construction meeting minutes distribution.
B. The CM/GC shall include the CxP on all Requests For Information (RFI) and Change Order Requests (COR) related to commissioned equipment and systems.
C. The CxP will regularly communicate with all members of the commissioning team, apprising them of commissioning progress and scheduling changes through memos, progress reports, etc.
D. The CM/GC will respond to the CxP’s deficiency record with resolution updates.
E. The CM/GC will provide documentation as required for the CxP to compile a final Commissioning Report which summarizes all of the tasks, findings, and documentation of the commissioning process. The report addresses the actual performance of the building systems in reference to the design intent and contract documents. The report includes a summary of commissioning activities, contact and warranty information, completed construction verification checklists, functional performance testing records, diagnostic monitoring results, identified deficiencies, recommendations for warranty review meeting and ongoing commissioning effort.

3.3 SUBMITTALS

A. Refer to Division 01 General Requirements and Section "Submittals" and relevant Division sections for requirements.
B. The CM/GC shall provide the CxP submittals related to the commissioned equipment to review for conformance to the Construction Documents as it relates to the commissioning process. The review is intended primarily to aid in the development of functional performance test procedures.
C. The CM/GC shall respond to request for additional information from the CxP as needed to facilitate the commissioning process.
D. The CxP may request additional design and operations narrative from the design team and Controls Contractor regarding sequences of operations.

3.4 START-UP and CONSTRUCTION VERIFICATION CHECKLISTS

The following procedures apply to all equipment to be commissioned, according to Section 1.7, Commissioning Scope.

A. Start-Up Plans:

1. The responsible contractors shall develop detailed start-up plans for all equipment to be commissioned. The CxP will review start-up plans to confirm that there is written documentation that each of the manufacturer-recommended procedures is completed.
2. Subcontractors and equipment suppliers schedule startup and checkout with the OPM, CM/GC and CxP.
3. All work to be installed in accordance with the manufacturer’s instructions. The subcontractors and vendors execute manufacturer installation procedures and start-up documentation. A copy of completed start-up checklists shall be provided to the CxP.
4. The start-up plans and documentation may be provided to the OPM and A/E for review.

B. Construction Verification Checklists:

1. The construction verification checklists are a formalized means to provide individual workers the criteria for a successful installation, adherence to the construction documents and to easily track construction progress.

COMMISSIONING of HVAC

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2. Each assembly, component, equipment, system and interface to be commissioned shall be verified by the installer at the site while work is underway and documented on the construction verification checklists. The contractor is responsible for successfully completing installations, documenting this on the construction verification checklist forms and correcting all deficiencies.

3. Construction verification checklists are developed by the CxP for all major equipment and systems being commissioned. The checklist documents all equipment components are installed and functional and confirms the as-built status of the equipment or system. These checklists also assist in confirming that the systems are complete and operational, so that the functional performance testing can be scheduled.

4. Construction verification checklists will be electronic and available via a web-based program. It is the contractor’s responsibility to have an electronic means of entering this data from on site.

5. Construction verification checklists shall be filled out and signed by the installing subcontractor for each piece of equipment. Only individuals who have completed or witnessed the line item task shall complete and sign the checklists.

6. Contractor shall periodically review the construction verification checklist schedule with the CxP allowing advance notice of activities of 5 business days so that the CxP may witness as deemed necessary.

7. Calibration of all sensors shall be included as part of the construction verification checklists performed by the Contractors.

C. Deficiencies, Non-Conformance, and Approval in Checklists and Startup:

1. The Subcontractors shall clearly list any items of the start-up and construction verification procedures not successfully completed at the bottom of the form or on an attached sheet. The procedures form and any outstanding deficiencies are provided to the CxP within two days of test completion.

2. The CxP will verify the accuracy of the completed start-up forms and construction checklists compared with actual field installation and recommends approval to the OPM.

3. If CxP identifies more than a 10% discrepancy rate during confirmation of construction verification checklists, the contractor shall correct all deficiencies and revalidate all items covered by that checklist and resubmit new checklists.

4. The cost of reconfirmation of construction verification checklists due to equipment or construction deficiencies is the responsibility of the contractor and subject to deductive change order at owner’s/construction manager’s discretion. Correction of deficiencies and revalidation are the responsibility of the contractor and are not subject to time extensions or delay claims.

3.5 FUNCTIONAL PERFORMANCE TESTING

A. Functional performance testing for each system in the commissioning scope shall be executed by the sub-contractor responsible for the startup and operational checkout of the system.

B. The following procedures apply to all equipment to be commissioned, according to Section 1.7, Commissioning Scope. This sub-section applies to all commissioning functional performance testing for all divisions.

C. Objectives and Scope: The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Construction Documents. Functional performance testing comprises a full range of tests to verify that all components, equipment, systems, and interfaces between systems operate correctly. This includes all operating modes, interlocks, control sequences, and responses to emergency conditions. All verification procedures are directed, witnessed, and documented by the CxP.
D. Development of Test Procedures: The CxP develops specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Prior to execution, the CxP provides the test procedures to the Sub(s) who review the tests for feasibility, safety, equipment and warranty protection. The CxP may submit the tests to the A/E team for review.

E. Equipment Protection: Provide provisions that will prevent system being damaged during system testing and commissioning including freeze protection.

F. Test Methods:

1. Functional performance testing and verification may be achieved by direct manipulation of system inputs (i.e. heating or cooling sensors), manipulation of system inputs with the building automation system (i.e. software override of sensor inputs), trend logs of system inputs and outputs using the building automation system, or short-term monitoring of system inputs and outputs using stand alone data loggers. A combination of methods may be required to completely test the complete sequence of operations. The CxP determines which method, or combination, is most appropriate.

2. Setup: Each test procedure is performed under conditions that simulate normal operating conditions as closely as possible. The Sub executing the test provides all necessary system modifications to produce the specified conditions (flows, pressures, temperatures, etc) necessary to execute the test. At completion of the test, the Sub returns all affected building equipment and systems to their pre-test conditions.

3. Sampling: Multiple identical pieces of non-life-safety or non-critical equipment may be functionally tested using a sampling strategy. The CxP shall establish sampling protocol with approval of the OPM, and at the time of testing select sample test locations for identical pieces of equipment. Where simulation of conditions or altering of setpoints or values is required to achieve an operating or failure mode for testing, the contractor must receive CxP approval. If, after three attempts at testing the specified sample percentage, failures are still present, then all remaining units are tested at the contractors’ expense.

G. Coordination and Scheduling: Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures.

H. Contractor shall coordinate functional performance testing with CxP, the construction manager, and the owner and notify them 5 business days prior to testing so that they may witness and document the test results. All contractors involved with specific assemblies, components, equipment, systems and interfaces shall have qualified installers and technicians present at the same time working together to perform testing and demonstrate correct performance through all operating and failure modes and compliance with contract documents and manufacturer’s recommendations.

I. With Owner and CM oversight, the CxP is responsible for witnessing functional performance testing and recording the results and deficiencies. The following sequential priorities are followed:

1. Equipment is not ”temporarily” started (for heating or cooling), until pre-start checklist items and all manufacturers’ pre-start procedures are completed and moisture, dust and other environmental and building integrity issues have been addressed.

2. Functional performance testing does not begin until construction verification, start-up, controls verification of installation (all sequences and points), and TAB is completed for a given system.

3. The controls system and equipment it controls are not functionally tested until all points have been calibrated and construction verification checklists are completed.
J. Contractors are responsible for completing and coordinating their work with all trades prior to testing, preplanning testing procedures, ensuring necessary staff and resources are on hand and expediting testing. This includes, but not limited to, completing testing and balancing by the HVAC contractor required for successful functional performance testing, pre-testing of the systems (completing FPT) prior to testing with CxP. Pre-testing will include submission of trending per the request of CxP. Failure to complete or coordinate work, preplan or have staff and resources available to carry out testing will result in retesting.

K. Problem Solving: The CxP may recommend solutions to deficiencies identified during functional testing. However, the burden of responsibility to solve, correct and retest deficiencies is with the CM/GC, Subcontractors and A/E.

3.6 HOT WATER HEATING SYSTEM (BOILERS, PUMPS, DISTRIBUTION)

A. Parties Responsible to Execute Functional Test:
   1. Vendor Support Representative
   2. Controls Contractor: Operate the controls, as needed
   3. HVAC mechanical contractor or vendor: Assist in testing sequences
   4. CxP: To witness and document testing

B. Integral Components or Related Equipment Being Tested: Pre-functional tests must be complete for all of the components listed below prior to performing this functional test.
   1. Boilers
   2. HW pumps
   3. HW pump VFDs
   4. Burner and blower
   5. Pressurized compression tank and air separation
   6. Water treatment and water makeup systems

C. Prerequisites:
   1. The applicable prerequisite checklist items listed in Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the pre-functional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods and Seasonal Test Requirements.
   1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

<table>
<thead>
<tr>
<th>Function / Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
</tr>
<tr>
<td>1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, shutdown, unoccupied &amp; manual modes and power failure. Test functionality of this piece of equipment or system in all control strategies or interlocks with which it is associated.</td>
</tr>
<tr>
<td>Function / Mode</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>2. Supply pump staging, bypass valve operation, if no VFD and HWT reset. VFD operation: modulation to minimum, control system PID, proportional band of speed vs controlling parameter, verification of program settings, alarms, etc.</td>
</tr>
<tr>
<td>3. Check all alarms and safeties (high and low pressure and temperature, etc.), PRV and flow switch functions</td>
</tr>
<tr>
<td>4. Test each possible lead boiler as lead boiler, and each pump as lead pump. Test pump lockouts.</td>
</tr>
<tr>
<td>5. Verify boiler inlet/outlet pressures with startup report and manufacturer’s recommendations.</td>
</tr>
<tr>
<td>6. Sensor and actuator calibration checks on: HWST, HWRT, pressure sensor controlling pump speed, mixing valve and other random checks (EMS readout against hand-held calibrated instrument must be within 0.5°F for temps. or within a tolerance equal to 10% of the pressure set point, with a test gage).</td>
</tr>
<tr>
<td>7. Constancy of differential pressure (pump control parameter)</td>
</tr>
<tr>
<td>8. Trend all temperature, pressure, speed and control points from the start of functional performance testing until Post Construction Phase is complete.</td>
</tr>
<tr>
<td>10. Water treatment, water levels, pressure and temperature safeties and alarms.</td>
</tr>
<tr>
<td>11. Verify schedules and set points to be reasonable and appropriate</td>
</tr>
</tbody>
</table>

E. Special Procedures (other equipment to test with, etc.; reference to function ID):
   1. False load boiler, if necessary.
   2. Testing of boiler safety valves.
   3. Boiler inspector’s tests.

F. Acceptance Criteria (referenced by function or mode ID):
   1. For the conditions, sequences, and modes tested, the boilers, integral components and related equipment respond to varying loads and changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.
   2. Boiler shall maintain the supply water set point to within +/- 3.0°F of set point dead band without excessive hunting.
   3. Pumping system and controls shall maintain the current desired pressure set point to within an amount equal to 10% of the set point value either side of the dead band without excessive hunting.

G. Sampling Strategy for Identical Units: No sampling, test all.

3.7 TERMINAL UNITS (FCU, FPT, VAV, CUH, UH)

A. Parties Responsible to Execute Functional Test:
   1. Controls Contractor: Operate the controls to activate the equipment.
   2. CxP to record results.
   3. Mechanical Contractor to make any adjustments.
B. Integral Components or Related Equipment Being Tested: Pre-functional tests must be complete for all of the components listed below prior to performing this functional test.

1. VAV Boxes w/ and w/o Reheat Coils
2. Radiation
3. Unit Heaters
4. Air Handling Systems

C. Prerequisites:

1. The applicable prerequisite checklist items listed in the Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the pre-functional checklists previously completed by the installer, before the beginning of functional testing.

<table>
<thead>
<tr>
<th>Function/Mode</th>
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<tbody>
<tr>
<td><strong>General</strong></td>
</tr>
<tr>
<td>1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, warm-up, shutdown, unoccupied &amp; manual modes and power failure and restoration. Test functionality of this piece of equipment or system in all control strategies or interlocks that it is associated with, including all damper, valve and fan functions.</td>
</tr>
<tr>
<td>2. Sensor activator calibration checks on: SAT, zone air temperature damper position and other random checks (EMS readout against visual or hand-held calibrated instrument must be within 0.5°F for temps. or within a tolerance equal to 10% of static pressure set point, with an inclined manometer)</td>
</tr>
<tr>
<td>3. Device and actuator calibration and stroke checks for heating coil valve and dampers</td>
</tr>
<tr>
<td>4. For the TU's tested, check the prefunctional checklist items.</td>
</tr>
<tr>
<td>5. Verify control parameters and set points to be reasonable and appropriate by reviewing the full program of 5% of all the TU's with each other for consistency. Verify the max. and min. cfm set points of all tested TU's against the control drawing and TAB values. Verify other TU programming parameters such as K-factors, dead bands, set points, stroke times, etc.</td>
</tr>
<tr>
<td>6. Verify proper operation of valve in both cooling and heating modes under occupied and unoccupied conditions.</td>
</tr>
<tr>
<td>7. Verify no hunting or significant overshoot by valves and dampers.</td>
</tr>
<tr>
<td>8. Verify by measurement, CCV &amp; HCV positive shutoff (no leak-thru)</td>
</tr>
<tr>
<td>9. All alarms (fan status, low limits, etc.)</td>
</tr>
<tr>
<td>10. Verify that TU is maintaining space set point temperatures and fans are being cycled as specified</td>
</tr>
<tr>
<td>11. Trend all temperature, pressure, speed and control points from the start of functional performance testing until Post Construction Phase is complete.</td>
</tr>
</tbody>
</table>
D. Functions/Modes Required To Be Tested, Test Methods:
   1. The following testing requirements are in addition to and do not replace any testing
      requirements elsewhere in this Specification.

E. Special Procedures (other equipment to test with, etc.; reference to function ID): None

F. Acceptance Criteria (referenced by function or mode ID):
   1. For the conditions, sequences and modes tested, the TU, integral components and
      related equipment respond to varying loads and changing conditions and parameters
      appropriately as expected, as specified and according to acceptable operating practice.
   2. Space temperature during occupied modes shall average within +/- 1°F of set point and
      always remain within 1°F of the ends of the dead band without excessive hunting of the
      coil valve or complaints of drafts or stuffiness from occupants.

G. Sampling Strategy for Identical:
   1. Units of the same type and function, but different in size, are considered identical for
      sampling purposes.
   2. Testing:
      a. Randomly test at least 25% of each group of identical equipment (the 1st sample).
         In no case test less than three units in each group. If 10% of the units in the first
         sample fail the functional performance tests, test another 10% of the group (the
         2nd sample). If 10% of the units in the 2nd sample fail, test all remaining units in
         the whole group, fully at the contractor’s expense. This sampling applies to the
         testing subsections. That is, if calibration is off on more than 10% of the tested
         piece of equipment, then another sample shall have calibrations checked, but not
         all other tests need to be done on the second sample.
   3. Monitoring:
      a. Twenty five percent of the total number of zones in the building, chosen by the
         Owner, shall be monitored. Within this 25%, shall be included a distribution of all
         air handlers, zones expected to have the greatest heating and cooling demand,
         perimeter and core zones and zones identified from the commissioning process
         that have exhibited potential problems.

3.8 PACKAGED DX SPLIT SYSTEM AIR CONDITIONING OR HEAT PUMP

A. Parties Responsible to Execute Functional Test:
   1. Controls Contractor: Operate the controls to activate the equipment.
   2. CxP: To witness and document testing.
   3. TAB Contractor to verify airflows.
   4. Unit Manufacturer’s Representative.

B. Integral Components or Related Equipment Being Tested:
   1. Pre-functional tests must be complete for all of the components listed below prior to
      performing this functional test.
      a. Unit (fans, coils, condenser, compressors, ducts, VFD)
C. Prerequisites:
   1. The applicable prerequisite checklist items listed in the Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the pre-functional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods:
   1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

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</tr>
<tr>
<td>2.</td>
<td>Supply air, and reset temp. control functions</td>
</tr>
<tr>
<td>3.</td>
<td>SF, RF and exhaust fan interlocks</td>
</tr>
<tr>
<td>4.</td>
<td>Compressor unloading &amp; condenser fan staging for head pressure control</td>
</tr>
<tr>
<td>5.</td>
<td>Damper interlocks and correct modulation in all modes, including fire and smoke dampers</td>
</tr>
<tr>
<td>6.</td>
<td>Temperature difference across cooling coils</td>
</tr>
<tr>
<td>7.</td>
<td>Verify TAB reported SF cfm with control system reading</td>
</tr>
<tr>
<td>8.</td>
<td>All alarms (low limits, high static, freezestat, etc.)</td>
</tr>
<tr>
<td>9.</td>
<td>Unit cooling capacity tests</td>
</tr>
<tr>
<td>10.</td>
<td>Sensor and actuator calibration checks on: SAT, RAT, and other random checks (EMS readout against hand-held calibrated instrument must be within 0.5°F for temps. or within a tolerance equal to 10% of static pressure set point, with an inclined manometer)</td>
</tr>
<tr>
<td>11.</td>
<td>Trend all temperature, pressure, speed and control points from the start of functional performance testing until Post Construction Phase is complete.</td>
</tr>
<tr>
<td>12.</td>
<td>Verify control strategies, schedules and set points to be reasonable and appropriate</td>
</tr>
</tbody>
</table>

E. Special Procedures (other equipment to test with, etc.; reference to function ID): None

F. Acceptance Criteria (referenced by function or mode ID):
   1. For the conditions, sequences and modes tested, the system, integral components and related equipment respond to varying loads and changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

G. Sampling Strategy: Test all units.

END OF PACKAGED DX SPLIT SYSTEM AIR CONDITIONING OR HEAT PUMP
3.9 EXHAUST FANS

A. Parties Responsible to Execute Functional Test

1. Controls Contractor: Operate the controls to activate the equipment.
2. CxP: To witness and document testing.
3. TAB Contractor to verify airflows.
4. Mechanical Contractor to make any adjustments.

B. Integral Components or Related Equipment Being Tested: Pre-functional checklists must be complete for all of the components listed below prior to performing this functional test.

1. Controls
2. Terminal equipment

C. Prerequisites: The applicable prerequisite checklist items shall be signed off prior to functional testing. The commissioning agent may spot-check misc. items and calibrations on the pre-functional checklists before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods:

<table>
<thead>
<tr>
<th>Function/Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
</tr>
<tr>
<td>1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, shutdown, unoccupied &amp; manual modes and power failure. Test functionality of this piece of equipment or system in all control strategies or interlocks that it is associated with.</td>
</tr>
<tr>
<td>2. Verify schedules and set points to be reasonable and appropriate</td>
</tr>
<tr>
<td>3. Function at fire alarm (off, depressurization, etc.)</td>
</tr>
<tr>
<td>4. Check TAB report record of sound power level tests and space pressures and compare to specifications</td>
</tr>
<tr>
<td>5. Sensor calibration checks on any controlling temperature or pressure sensor</td>
</tr>
</tbody>
</table>

E. Special Procedures (other equipment to test with, etc.; reference to function ID)

1. None.

F. Acceptance Criteria (referenced by function or mode ID)

1. For the conditions, sequences and modes tested, the fans, integral components and related equipment respond to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

END OF EXHAUST FANS
3.10 BUILDING AUTOMATION SYSTEM (BAS)

A. Parties Responsible to Execute Functional Test:
   1. Controls Contractor: Operate the controls to activate the equipment.
   2. CxP: To witness and document testing.

<table>
<thead>
<tr>
<th>Function/Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. All specified functions and features are set up, debugged and fully operable</td>
</tr>
<tr>
<td>2. Power failure and battery backup and power-up restart functions</td>
</tr>
<tr>
<td>3. Specified trending and graphing features demonstration</td>
</tr>
<tr>
<td>4. Global commands features</td>
</tr>
<tr>
<td>5. Security and access codes</td>
</tr>
<tr>
<td>6. Occupant over-rides (manual, telephone, key, keypad, etc.)</td>
</tr>
<tr>
<td>7. O&amp;M schedules and alarms</td>
</tr>
<tr>
<td>8. Scheduling features fully functional and setup, including holidays</td>
</tr>
<tr>
<td>9. Included features not specified to be setup are installed (list)</td>
</tr>
<tr>
<td>10. Demonstrate functionality of field panels using local operator keypads and local ports (plug-ins) using portable computer/keypad</td>
</tr>
<tr>
<td>11. All graphic screens and value readouts completed</td>
</tr>
<tr>
<td>12. Set point changing features and functions</td>
</tr>
<tr>
<td>13. Communications to remote sites</td>
</tr>
<tr>
<td>14. Sensor calibrations</td>
</tr>
<tr>
<td>15. Final as-buils or redlines (per spec) control drawings, final points list, program code, set points, schedules, warranties, etc. per specs, submitted for O&amp;Ms.</td>
</tr>
<tr>
<td>16. Verify that points that are monitored only, having no control function, are checked for proper reporting to BAS.</td>
</tr>
<tr>
<td>17. Optional Start/Stop Routine.</td>
</tr>
<tr>
<td>18. Final room numbers programmed into system.</td>
</tr>
<tr>
<td>19. Fire alarm interlocks and response</td>
</tr>
<tr>
<td>20. Demand limiting (including over-ride of limiting)</td>
</tr>
<tr>
<td>21. Sequential staging ON of equipment</td>
</tr>
<tr>
<td>22. All control strategies and sequences not tested during controlled equipment testing</td>
</tr>
<tr>
<td>23. Other integrated tests specified in the contract documents</td>
</tr>
<tr>
<td>24. Emergency power operation and return to normal power.</td>
</tr>
<tr>
<td>25. Fire protection and suppression systems</td>
</tr>
</tbody>
</table>

B. Integral Components or Related Equipment Being Tested: Pre-functional tests must be complete for all of the components listed below prior to performing this functional test.
   1. Building Automation System
   2. All pre-functional checklists of controlled equipment
C. Prerequisites:
   1. The applicable prerequisite checklist items listed in the Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning provider will also spot-check misc. items and calibrations on the pre-functional checklists previously completed by the installer, before the beginning of functional testing.

D. A significant part of the BAS functional testing requirements is the successful completion of the functional tests of equipment the BAS controls or interlocks with. Uncompleted equipment functional tests or outstanding deficiencies in those tests lend the required BAS functional testing incomplete.

E. Integral or stand-alone controls are functionally tested with the equipment they are attached to, including any interlocks with other equipment or systems and thus are not covered under the BAS testing requirements, except for any integrated functions or interlocks listed below.

F. In addition to the controlled equipment testing, the following tests are required for the BAS, where features have been specified. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in the specifications.

G. Special Procedures (other equipment to test with, etc.; reference to function ID): None

H. Acceptance Criteria (referenced by function or mode ID):
   1. For the conditions, sequences and modes tested, the BAS, integral components and related equipment respond to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

END OF BUILDING AUTOMATION SYSTEM (BAS)

3.11 TEST AND BALANCE WORK (TAB)

A. Parties Responsible to Execute Functional Test:
   1. TAB Contractor: Perform checks using test instruments.
   2. Controls Contractor: Operate the controls to activate the equipment.
   3. CxP: To witness and document testing.

B. Integral Components or Related Equipment Being Tested: Pre-functional tests must be complete for all of the components listed below prior to performing this functional test.
   1. TAB water-side
   2. TAB air-side
   3. TAB equipment and systems
   4. TAB electrical

C. Prerequisites
   1. The applicable prerequisite checklist items listed in the beginning of this Section shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the pre-functional checklists previously completed by the installer, before the beginning of functional testing.
D. Purpose:

1. The purpose of this test is to spot check the TAB work to verify that it was done in accordance with the contract documents and acceptable practice and that the TAB report is accurate.

E. The following tests and checks will be conducted. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

<table>
<thead>
<tr>
<th>Test or Check</th>
</tr>
</thead>
</table>
| 1. A random sample of up to 5% the TAB report data shall be selected for verification (air velocity, air or water flow rate, pressure differential, electrical or sound measurement, etc.). The original TAB contractor will execute the checks, witnessed by the commissioning authority. The TAB contractor will use the same test instruments as used in the original TAB work.

A failure of more than 10% of the selected items of a given system shall result in the failure of acceptance of the system TAB report and the TAB contractor shall be responsible to rebalance the system, provide a new system TAB report and repeat random verifications of the new TAB report.

The random testing will include the verification of minimum outdoor air intake flows at minimum, maximum and intermediate total airflow rates for 100% of the air handlers. Other selected data to be verified will be made known upon day of testing. |
| 2. Verify that final settings of all valves, splitters, dampers and other adjustment devices have been permanently marked by the TAB Contractor. |
| 3. Verification that the air system is being controlled to the lowest possible static pressure while still meeting design loads, less diversity. This shall include a review of TAB methods, control set points established by TAB and a physical verification of at least one leg from fan to diffuser having all balancing dampers wide open and that during full cooling of all TUs taking off downstream of the static pressure sensor, the TU on the critical leg has its damper 90% or more open. |
| 4. Verification that the water system is being controlled to the lowest possible pressure while still meeting design loads, less diversity. This shall include a review of TAB methods, control set points established by TAB and a physical verification of at least one leg from the pump to the coil having all balancing valves wide open and that during full cooling the cooling coil valve of that leg is 90% or more open. |
Failure of an item is defined as follows:
For airflow of supply and return: a deviation of more than 10% of instrument reading
For minimum outside airflow: 20% of instrument reading (30% for reading at intermediate supply flow for inlet vane or VFD OSA compensation system using linear proportional control)
For temperatures: a deviation of more than 1°F
For air and water pressures: a deviation of more than 10% of full scale of test instrument reading
For sound pressures: a deviation of more than 3 decibels. (Variations in background noise must be considered)

Examples of a “system” are: the air distribution system served by one air handler or the hydronic hot water supply system served by a boiler. Systems can be defined smaller if inaccuracies in TAB work within the smaller defined system will have little or no impact on connected systems.

Cooling season, Heating season or Both. “Design” means within 5° of season design (ASHRAE 2 1/2%), or 95% of loading design. A blank cell denotes no special seasonal test is required and that test can be executed during any season, if condition simulation is appropriate.

F. Special Procedures (other equipment to test with, etc.; reference to function ID): None
G. Required Monitoring: None
H. Acceptance Criteria (referenced by function or mode ID): Provided in footnote to test table above.
I. Sampling Strategy for Identical Units: Described in test table above.

END OF TEST AND BALANCE WORK (TAB)

3.12 AIR HANDLING UNITS (RECIRCULATING AND 100% O.A.)

A. Parties Responsible to Execute Functional Test
   1. Controls Contractor: Operate the controls to activate the equipment.
   2. CxP: To witness and document testing.
   3. TAB Contractor to verify air and water flows.
   4. Mechanical Contractor to fix any problems.
   5. Unit Manufacturer's Representative.

B. Integral Components or Related Equipment Being Tested: Pre-functional tests must be complete for all of the components listed below prior to performing this functional test.
   1. Chilled Water System to cooling section
   2. Hot water heating system or gas to unit heating section

C. Prerequisites:
   1. The applicable prerequisite checklist items listed in the Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the pre-functional checklists previously completed by the installer, before the beginning of functional testing.
D. Functions/Modes Required To Be Tested, Test Methods:

1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

<table>
<thead>
<tr>
<th>Function / Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
</tr>
<tr>
<td>1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, shutdown, unoccupied &amp; manual modes and power failure. Test functionality of this piece of equipment or system in all control strategies or interlocks that it is associated with.</td>
</tr>
<tr>
<td>2. Hot water coil and face and bypass dampers temperature control functions</td>
</tr>
<tr>
<td>3. Economizer functions</td>
</tr>
<tr>
<td>4. SF, RF and exhaust fan interlocks</td>
</tr>
<tr>
<td>5. Damper interlocks and correct modulation in all modes, including fire and smoke dampers and CO₂ control</td>
</tr>
<tr>
<td>6. Temperature difference across heating and cooling coils</td>
</tr>
<tr>
<td>7. Smoke detectors and smoke evac control from fire alarm control panel.</td>
</tr>
<tr>
<td>8. Verify TAB reported SF and RF cfm with control system reading</td>
</tr>
<tr>
<td>9. All alarms (low limits, high static, freezestat, etc.)</td>
</tr>
<tr>
<td>10. Supply and return fans static pressure and volume matching control</td>
</tr>
<tr>
<td>11. Sensor and actuator calibration checks on: SAT, MAT, OSAT, CO₂ economizer and RA dampers and other random checks (EMS readout against hand-held calibrated instrument must be within 0.5°F for temps. or within a tolerance equal to 10% of static pressure set point, with an inclined manometer)</td>
</tr>
<tr>
<td>12. Trend all temperature, pressure, speed and control points from the start of functional performance testing until Acceptance Phase is complete. Provide CA with all requested data until approved.</td>
</tr>
<tr>
<td>13. Verify control strategies, schedules and set points to be reasonable and appropriate</td>
</tr>
</tbody>
</table>

E. Special Procedures (other equipment to test with, etc.; reference to function ID): None

F. Acceptance Criteria (referenced by function or mode ID):

1. For the conditions, sequences and modes tested, the system, integral components and related equipment respond to varying loads and changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

G. Sampling Strategy: Test all units.

END OF AIR HANDLING UNITS (RECIRCULATING AND 100% O.A.)
3.13 DOCUMENTATION, NON-CONFORMANCE, AND APPROVAL OF TESTS

A. Documentation:
   1. The CxP witnesses and documents the results of all functional performance tests using forms developed for that purpose. Prior to testing, these forms are provided to the OPM for review and approval.

B. Non-Conformance:
   1. The CxP records the results of the functional test on the procedure or test form. All deficiencies identified during the verification testing are documented on a standard Issues Log form and reported to the project manager, contractors, and sub-contractors. The deficiency report includes all details of the components or systems found to be non-compliant with the parameters of the test plans. The report details the adjustments or alterations required to correct system operation and identifies the responsible party.
   2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxP. In such cases the deficiency and resolution will be documented on the procedure form.
   3. Deficiencies that cannot be corrected during testing will be documented on the Issues Log and subject to retest. Retesting will continue until no deficiencies remain or by Owner’s request.
   4. Retesting is required when testing cannot be successfully completed. Deficiencies requiring include:
      a. Incomplete work and/or coordination with others.
      b. Inadequate preparation of systems for testing.
      c. Inadequate preplanning.
      d. Inadequate staff, equipment, tools or resources for testing.
      e. Material, equipment or construction deficiencies.
      f. Incomplete or failed test due to reasons under the Contractor’s responsibility.
   5. If there is a dispute about a deficiency or who is responsible:
      a. The deficiency is documented on the Issues Log and a copy given to the OPM and CM/GC.
      b. Resolutions are made at the lowest management level possible. Additional parties are brought into the discussions as needed. Final interpretive authority is with the A/E team. Final acceptance authority is with the Project Manager. The CxP documents the resolution process.
      c. Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency and notifies the CxP that the equipment is ready to be retested.
      d. The CxP reschedules the test and the test is repeated until satisfactory performance is achieved.

C. Cost of Retesting:
   1. The cost of retesting is the responsibility of the contractor and subject to deductive change order. Correction of deficiencies and retesting are the responsibility of the contractor and are not subject to time extensions or delay claims.

D. Approval:
   1. The CxP makes formal approval of the functional performance test after review. The CxP recommends acceptance of each test to the OPM. The OPM gives final approval on each test.
3.14 OWNER’S TRAINING
A. Refer to Division 01 General Requirements and Section "Demonstration and Training" and relevant Division sections for requirements.
B. The Contractor is responsible for developing a cohesive training plan for all Divisions and Sections of work where training is specified. See technical sections for specified minimum training hours for each component and system.
C. The CM/GC shall provide the CxP a preliminary training plan and schedule related to the commissioned equipment to review and finalize incorporating comments received. The plan should include agendas including topics and objectives to be covered for each section, the instructor’s name and contact information, the anticipated duration and schedule for each session, a formal training record listing of attendees and a training evaluation form. Develop the training schedule including number of hours for each component or system in coordination with the CxP and CM that complies with the owner’s and CxP’s personnel availability.
D. The CxP shall provide each trainee with a Training Evaluation Form and at completion of training collect forms for review. Based on evaluations and OPM training review, contractor shall repeat training sessions which were determined were inadequate or incomplete.

3.15 O&M DATA and CLOSEOUT SUBMITTALS
A. Refer to Division 01 General Requirements and Section "Closeout Submittals" and relevant Division sections for requirements.
B. The CM/GC shall provide the CxP closeout submittals related to the commissioned equipment to review and compile into a Recommissioning Systems Manual as required.

3.16 DEFERRED TESTING
A. Unforeseen Deferred Tests: If any test cannot be completed due to the building structure, required occupancy condition, or other deficiency, the functional testing may be delayed upon approval of the OPM. These tests are conducted in the same manner as the seasonal tests as soon as possible.
B. Seasonal Testing: Seasonal variation in operations or control strategies may require additional testing during the opposite season to verify performance of the HVAC system and controls. During the warranty period, seasonal testing and other deferred testing is completed as required to fully test all sequences of operation. The CxP coordinates these activities. Tests are executed and documented, with deficiencies corrected by the appropriate Subcontractors. Any final adjustments to the Operation and Maintenance manuals and as-builds due to the testing are also completed.
1. Two additional functional performance sessions are to be completed for the following systems.
   a. Air Handling Units / Rooftop Units
   b. Chilled Water Systems
   c. Heating Hot Water Systems

END OF SECTION 230800
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes a fully Integrated Building Automation System (BAS) to control HVAC systems and components, including control of all terminal heating and cooling units and other equipment not supplied with factory-supplied controls.

B. The Building Automation System (BAS) manufacturer shall furnish and install a fully integrated campus wide building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified. The system must be capable to interface and integrate with other technology systems on campus, including but not limited to fire alarm, video surveillance, access control and lighting control system.

C. The system shall utilize an open architecture that shall support equipment and systems from multiple vendors. The physical network for the systems, the cable plant, the logical network for the systems and the networking protocols shall be open architectures, supporting multiple applications and equipment manufacturers. The system shall use the campus wide fiber optic Ethernet network for communication between buildings.

1.2 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

H. RTC: Real time clock.

I. BAS: Building Automation System.

J. NRC: Network Router/Controller.

K. SDCU: Stand Alone Digital Control Units.

L. APW: Administration and Programming Workstation.

M. WOW: Web-Based Operator Workstation.

N. ODBC: Open Data Base Connectivity.

1.3 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
   a. Chilled Water Temperature: Plus or minus 0.5 deg F (0.25 deg C).
   b. Hot Water Temperature: Plus or minus 1 deg F (0.5 deg C).
   c. Water Flow: Plus or minus 5 percent of reading.
   d. Water Pressure: Plus or minus 2 percent of reading.
   e. Space Temperature: Plus or minus 1 deg F (0.5 deg C).
   f. Ducted Air Temperature: Plus or minus 1 deg F (0.5 deg C).
   g. Outside Air Temperature: Plus or minus 2 deg F (1.0 deg C).
   h. Dew Point Temperature: Plus or minus 3 deg F (1.5 deg C).
   i. Temperature Differential: Plus or minus 0.25 deg F (0.15 deg C).
   j. Relative Humidity: Plus or minus 3 percent of reading.
   k. Airflow (Pressurized Spaces): Plus or minus 3 percent of reading.
   l. Airflow (Terminal): Plus or minus 10 percent of reading.
   m. Air Pressure (Space): Plus or minus 10 percent of reading.
   n. Air Pressure (Ducts): Plus or minus 1 percent of reading.
   o. Carbon Monoxide: Plus or minus 5 percent of reading.
   p. Carbon Dioxide: Plus or minus 50 ppm.
   q. Electrical: Plus or minus 5 percent of reading.

1.4 SEQUENCE OF OPERATION
   A. Refer to Division 23 Section "Sequence of Operations for HVAC Controls."

1.5 SUBMITTALS
   A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."
1.6  ACTION SUBMITTALS

A.  Shop Drawings:  Contractor shall provide shop drawings or other submittals on all hardware, software, and installation to be provided. No work may begin on any segment of this project until submittals have been successfully reviewed for conformity with the design intent. Six copies are required. All drawings shall be prepared on a CAD system that produces drawing files compatible with AutoCAD Release 2012 or higher and be provided on USB 2.0 or better memory device, Portable Document Format (PDF) files. Provide one (1) full-size color drawings. When manufacturer’s cut sheets apply to a product series rather than specific products, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Submittals shall include:

1.  Direct Digital Control System Hardware:
   a.  A complete bill of materials of equipment to be used indicating quantity, manufacturer, model number, and other relevant technical data.
   b.  Manufacturer’s description and technical data, such as performance curves, product specification sheets, and installation/maintenance instructions for the items listed below and other relevant items not listed below:
      1)  Direct Digital controller (controller panels).
      2)  Transducers/Transmitters.
      3)  Sensors (including accuracy data).
      4)  Actuators.
      5)  Valves.
      6)  Relays/Switches.
      7)  Control Panels.
      8)  Power Supply.
      9)  Batteries.
     10)  Operator Interface Equipment.
     11)  Wiring.
   c.  Wiring diagrams and layouts for each control panel. Show all termination numbers.
   d.  Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware.

2.  Central System Hardware and Software:
   a.  A complete bill of material of equipment used, indicating quantity, manufacturer, model number and other relevant technical data.
   b.  Manufacturer’s description and technical data, such as product specification sheets and installation/maintenance instructions for the items listed below and other relevant items not listed below:
      1)  Central Processing Unit.
      2)  Monitors.
      3)  Printers.
      4)  Keyboard.
      5)  Power Supply.
      6)  Battery Backup.
      7)  Interface Equipment Between CPU and Control Panels.
      8)  Operating System Software.
      9)  Operator Interface Software.
10) Color Graphic Software.
11) Third-Party Software.

c. Schematic diagrams of all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers’ model numbers and functions. Show all interface wiring to the control system.
d. Riser diagrams of wiring between central control unit and all control panels.
e. A list of the color graphic screens to be provided. For each screen, provide a conceptual layout of pictures and data and show or explain which other screens can be directly accessed.

3. Controlled Systems:
   a. A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system.
   b. A schematic wiring diagram for each controlled system. Each schematic shall have all elements labeled. Where a control element is the same as that shown on the control system schematic, it shall be labeled with the same name. All terminals shall be labeled.
   c. An instrumentation list for each controlled system. Each element of the controlled system shall be listed in table format. The table shall show element name, type of device, manufacturer, model number and product data sheet number.
   d. A mounting, wiring, and routing plan-view drawing. The drawing shall be done in 1/4 inch scale. The design shall take into account HVAC, electrical and other systems’ design and elevation requirements. The drawing shall show the specific location of all concrete pads and bases and any special wall bracing for panels to accommodate this work. The plan view drawings shall include all Tier I communication trunk wiring and connections to existing BAS infrastructure.
   e. A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.
   f. A point list for each system controller including both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, and the location of the I/O device. Software flag points, alarm points, etc.

4. Quantities of items submitted shall be reviewed but are the responsibility of the Contractor.

5. A description of the proposed process along with all report formats and checklists to be used in Part 3: "Control System Demonstration and Acceptance."

6. A BACnet Protocol Implementation Conformance Statement (PICS) for each type of controller and operator interface included in the submittal.

B. Schedules:
   1. Within one month of contract award, provide a schedule of the work indicating the following:
      a. Intended sequence of work items.
      b. Start dates of individual work items.
      c. Duration of individual work items.
      d. Planned delivery dates for major material and equipment and expected lead times.
      e. Milestones indicating possible restraints on work by other trades or situations.
2. Provide monthly written status reports indicating work completed, revisions to expected delivery dates, etc. An updated project schedule shall be included.

1.7 CLOSEOUT SUBMITTALS

A. Operations and Maintenance Data:

1. Operation and Maintenance (O & M) Manual. This shall include as-built versions of the submittal product data. In addition to the information required for submittals, the O & M manual shall include:
   a. Names, addresses, and 24-hour telephone numbers of contractors installing equipment and the control systems and service representatives of each.
   b. Operators Manual with procedures for operating the control systems, including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.
   c. One set of Programming Manuals with a description of the programming language (including syntax), statement descriptions (including algorithms and calculations used), point database creation and modification, program creation and modification, and use of the editor.
   d. Engineering, Installation and Maintenance Manual(s) that explain how to design and install new points, panels, and the hardware; preventive maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.
   e. A listing and documentation of all custom software created using the programming language, including the set points, tuning parameters, and object database. One set of magnetic/optical media containing files of the software and database also shall be provided. All custom software and programming shall include all final modifications for each piece of equipment shall be included in the final record software including all tuning and parameter setpoints determined during TAB and Commissioning activities.
   f. One set of magnetic/optical media containing files of the software and database also shall be provided.
   g. A list of recommended spare parts with part numbers and suppliers.
   h. Complete original issue documentation, installation, and maintenance information for all third-party hardware provided, including computer equipment and sensors.
   i. Complete original issue diskettes for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
   j. Licenses, guarantees, and warranty documents for all equipment and systems.
   k. Recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions.

B. Project Record Documents: Upon completion of installation, submit three copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and shall include:

1. Project Record Drawings. These shall be as-built versions of the submittal shop drawings. One set of optical media including CAD, .DWG, or .DXF drawing files also shall be provided. Provide One set of Visio Files electronically to the Owner.
2. Final Field Quality Control Test Reports:
   a. Testing and Commissioning Reports and Checklists. Completed versions of all reports and checklists, along with all trend logs, used to meet the requirements of Part 3: “Control System Demonstration and Acceptance.”

3. Training Manuals: The contractor shall provide a course outline and training manuals for all training classes at least six weeks prior to the first class. The engineer may modify any or all of the training course outline and training materials, to meet the needs of the owner. Review and approval by the engineer shall be completed at least three weeks prior to the first class.

4. Include locations of controllers on Record Drawings including panel/controller address.

5. Provide laminated control one line diagram for each control panel.

6. Provide Control Power Transformer Schedule as a part of the project record drawings. Schedule shall include at a minimum the following:
   a. Circuit number
   b. Controller designation
   c. Devices
   d. Equipment served

1.8 QUALITY ASSURANCE

A. Codes and Standards:
   1. Electrical Standards: Provide electrical components of direct digital control system which have been UL-listed and labeled, and comply with NEMA standards.
   2. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for direct digital control systems.
   3. NFPA Compliance: Comply with NFPA 90A “Standard for the Installation of Air Conditioning and Ventilating Systems” where applicable to controls and control sequences.
   4. UL Compliance: Provide direct digital control devices which are UL listed as a signal appliance with listings as indicated below.
   5. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Digital control devices shall be listed and labeled by a NRTL. The term “NRTL” shall be as defined in OSHA Regulation 1910.7.
   6. Comply with National Electrical Code (NFPA 70) 2011 edition. Work and materials shall conform to and be executed, inspected and tested in accordance with the latest edition of the National Electric Code and with the governing rules and regulations of federal, state and local governmental agencies.

B. The BAS system shall be designed and installed, commissioned and serviced by manufacturer employed, factory trained personnel. Manufacturer shall have an in-place support facility with 40 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment. Distributors or licensed installing contractors are not acceptable.

C. The manufacturer shall provide full time, on site, experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the BAS.
D. The Bidder shall be regularly engaged in the manufacturing, installation and maintenance of BAS systems and shall have a minimum of ten (10) years of demonstrated technical expertise and experience in the manufacture, installation and maintenance of BAS systems similar in size and complexity to this project. A maintained service organization consisting of at least ten (10) competent servicemen for a period of not less than ten years and provide a list of 10 projects, similar in size and scope to this project, completed within the last five years.

E. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer’s latest standard design and complies with the specification requirements.

F. [THIS PARAGRAPH AND SUBPARAGRAPH SHALL BE REVIEWED BY THE DESIGN ENGINEER AND DELETED IF BAS INSTALLATION IS NOT PART OF AN ENGINEERED SMOKE CONTROLLED SYSTEM REQUIRING COMPLIANCE WITH UL 864] All BAS system controllers shall be UL listed under Standard UL 916, category PAZX; Standard ULC C100, category UUKL7; and under Standard UL 864, categories UUKL, UDTZ, and QVAX.

1. Entire BAS system shall be UL864/UUKL listed for smoke control applications.

G. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

H. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-0-2 (Model for Quality Assurance in Production, Installation, and Servicing) and ISO-150001 (The application of well-accepted business management principles to the environment). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

I. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels to current level of technology, and extend new field panels on a previously installed network. Compatibility shall also be defined as the ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers or protocol converters.

J. Single source responsibility of supplier shall be the complete installation and proper operation of the control systems and shall include debugging and proper calibration of each component in the entire system.

K. Design and build all system components to be fault-tolerant.

1. Satisfactory operation without damage at 110% and 85% of rated voltage and at plus 3 Hertz variation in line frequency.
2. Static, transient and short-circuit protection on all inputs and outputs.
3. Protect communication lines against incorrect wiring, static transients and induced magnetic interference.
4. Network-connected devices to be A.C. coupled or equivalent so that any single device failure will not disrupt or halt network communication.
5. All real time clocks to be battery-back for a minimum 72 hours.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
B. System Software: Update to latest version of software at Project completion.

1.10 COORDINATION

A. Coordinate location of thermostats, humidistsats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 28 Section "Intrusion Detection" to achieve compatibility with equipment that interfaces with that system and with building master clock.

C. Coordinate equipment with Division 28 Section "Access Control" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate equipment with Division 27 Section "Clock Systems" to achieve compatibility with equipment that interfaces with that system.

E. Coordinate equipment with Division 28 Section "PLC Electronic Detention Monitoring and Control Systems" to achieve compatibility with equipment that interfaces with that system.

F. Coordinate equipment with Division 26 Section "Network Lighting Controls" to achieve compatibility with equipment that interfaces with that system.

G. Coordinate equipment with Division 28 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.

H. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

I. Coordinate equipment with Division 26 Section "Electrical Power Management System" to achieve compatibility of communication interfaces.

J. Coordinate equipment with Division 26 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.

K. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

L. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

M. Refer to other Division 23 sections for installation of instrument wells, valve bodies, and dampers in mechanical systems.

N. Refer to applicable Division 26 sections for the following work:

1. Power supply wiring from power source to power connection on motor and unit control panels. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

2. Electrical Contractor shall provide 120 volt, 20 amp dedicated circuits and circuit breakers in emergency power panels for all control systems.

3. The entire building management system except terminal equipment shall be operative under emergency power conditions.

O. Provide the following electrical work as work of this section, complying with requirements of applicable Division 26 and 27 sections:

1. Control wiring between field-installed controls, indicating devices, and unit control panels consistent with ANSI/TIA/EIA-862.
2. Power wiring for DDC controllers and all other control system components. Provide service from spare 20A circuit breakers in nearest emergency power panel.

3. All monitoring and control wiring required for controls and instrumentation consisting with ANSI/TIA/EIA-862.

4. Provide UPS (battery back-up) to assure uninterrupted DDC system operation during switch-over between normal to emergency power for trunk operation and controllers except terminal use devices and where otherwise indicated on the plans.

5. Data wiring for connections to campus wide Ethernet structure.

1.11 EXTRA MATERIAL

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Replacement Materials: [THE DESIGN ENGINEER SHALL CONFIRM THE EXTRA MATERIALS TO BE PROVIDED AS PART OF THE WORK WITH FROEDTERT FACILITIES MANAGEMENT PRIOR TO ISSUANCE FOR BIDDING. ITEMS TO CONSIDER ARE VAV CONTROLLERS, SMALL CONTROL VALVES, DAMPER MOTORS, SENSORS, ETC.]

1.12 WARRANTY

A. Warrant all work as follows:

1. Labor and materials for the control system specified shall be warranted free from defects for a period of 12 months after final completion and acceptance. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. The contractor shall respond to the Owner’s requires for warranty service within 24 hours during normal business hours.

2. All work shall have a single warranty date, even when the Owner has received beneficial use due to an early system start-up. If the work specified is split into multiple contracts or a multi-phase contract, then each contract or phase shall have a separate warranty start date and period.

3. At the end of the final start-up, testing, and commissioning phase, if equipment and systems are operating satisfactorily to the Engineer, the Engineer shall sign certificates certifying that the control system’s operation has been tested and accepted in accordance with the terms of this specification. The date of acceptance shall be the start of warranty.

4. Operator workstation software, project-specific software, graphic software, database software, and firmware updates that resolve known software deficiencies as identified by the contractor shall be provided at no charge during the warranty period. Any upgrades or functional enhancements associated with the above-mentioned items also can be provided during the warranty period for an additional charge to the Owner by purchasing an in-warranty service agreement from the Contractor. Written authorization by the Owner must, however, be granted prior to the installation of any of the above-mentioned items.

5. Exception: The contractor shall not be required to warrant reused devices, except for those that have been rebuilt and/or repaired. The Contractor shall warrant all installation labor and materials, however, and shall demonstrate that all reused devices are in operable condition at the time of Engineer’s acceptance.
PART 2 - PRODUCTS

2.1 MATERIALS

A. Manufacturers: Subject to compliance with requirements, provide control system by one of the following:
   1. For work in areas with existing building automation systems and equipment to remain: match the existing control system
   2. For new work or where the existing system will be completely demolished and replaced:
      a. Automated Logic and Control.
      b. Johnson Controls, Inc.

B. Installers: The control system shall be installed by a branch or franchise office of an acceptable manufacturer.

C. All products used in this project installation shall be new and currently under manufacture and shall have been applied in similar installations for a minimum of two years. Do not use this installation as a product test site unless explicitly approved in writing by an Owner’s representative. Spare parts shall be available for at least five years after completion of this contract.

2.2 COMMUNICATION

A. General:
   1. The Building Automation System (BAS) shall consist of Network Router/Controllers (NRCs), a family of Standalone Digital Control Units (SDCUs), Administration and Programming Workstations (APWs), Web-based Operator Workstations (WOWs), and one File Server to support system configurations where more than three operator workstations are required. The BAS shall provide control, alarm detection, scheduling, reporting and information management for the entire facility, and Wide Area Network (WAN) if applicable, from a single Open Data Base Connectivity (ODBC) compliant database.
   2. The system shall be designed with a top-level 10/100/1000bT Ethernet network, using the BACnet/IP protocol. A sub-network using the BACnet MS/TP protocol, with a minimum of 76.8kb speed, shall connect the local, stand-alone controllers with Ethernet-level controller/routers. The use of ARCNET, LONworks, RS-232 serial communications, or BACnet Ethernet for these controllers is prohibited.

B. Level 1 Network Description:
   1. Level 1, the main backbone of the system, shall be an Ethernet 10/100/1000bT LAN/WAN, using BACnet/IP as the communications protocol. Network Router/Controllers, Operator Workstations, and the Central File Server shall connect directly to this network without the need for Gateway devices.

C. Level 2 Network Description:
   1. Level 2 of the system shall consist of one or more BACnet MS/TP field buses managed by the Network Router/Controllers. Minimum speed shall be 76.8kbps. The Level 2 field bus consists of an RS485, token passing bus that supports up to 127 Standalone Digital Control Units (SDCUs) for operation of HVAC equipment.
D. BAS LAN Segmentation:
   1. The BAS shall be capable of being segmented, through software, into multiple local area networks (LANs) distributed over a wide area network (WAN), sharing a single file server. This enables workstations to manage a single LAN (or building), and/or the entire system with all devices being assured of being updated by and sharing the most current database. In the case of a single workstation system, the workstation shall contain the entire database – with no need for a separate file server.

E. Standard Network Support:
   1. All NRCs, Workstation(s) and File Server shall be capable of residing directly on the Owner’s Ethernet TCP/IP LAN/WAN with no required gateways. Furthermore, the NRC’s, Workstation(s) and File Server shall be capable of using standard, commercially available, off-the-shelf Ethernet infrastructure components such as routers, switches and hubs. With this design the Owner may utilize the investment of an existing or new enterprise network or structured cabling system. This also allows the option of the maintenance of the LAN/WAN to be performed by the Owner’s Information Systems Department as all devices utilize standard TCP/IP components.

F. System Expansion:
   1. The BAS system shall be scalable and expandable at all levels of the system using the same software interface, and the same Level 1 and Level 2 controllers. Systems that require replacement of either the workstation software or field controllers in order to expand the system shall not be acceptable.
   2. The BAS shall be expandable to include Security and Access Control functions at any time in the future with no additional workstations, front-end software or Level 1 controllers required. Ethernet-based security/card access controllers shall be able to be added to the existing Level 1 network, to perform security and card access applications. In this way, an Owner’s existing investment in wiring infrastructure may be leveraged and the cost and inconvenience of adding new field bus wiring will be minimized.
   3. Additional web-based operator licenses shall be added in the field through an upgrade of the web server’s security key, with no re-programming required. The system shall use the same application programming language for all levels: Operator Workstation, Network Router/Controller, and Standalone Digital Control Unit. Furthermore, this single programming language shall be used for all applications: environmental control, card access control, intrusion detection and security, lighting control, leak detection / underground storage tank monitoring, and digital data communication interfaces to third party microprocessor-based devices.

G. Support For Open Systems Protocols:
   1. All hardware and software included under this section shall conform to BACnet standard 135-2001, to promote interoperability between building subsystems. Additionally, the BAS design must include solutions for the integration of the following "open systems" protocols: LonTalk™, Modbus, and digital data communication to third party microprocessors such as chiller controllers, fire panels and variable frequency drives (VFDs).
   2. The system shall also provide the ability to program custom ASCII communication drivers that will reside in a BACnet Gateway, for communication to third party systems and devices. These drivers will provide real time monitoring and control of the third party systems. Once programmed, these data points shall be monitored and controlled in exactly the same manner as native BAS data points.
2.3 NETWORK ROUTER/CONTROLLERS (NRCS)

A. General:

1. Network Router Controllers shall combine both network routing functions and control functions into a single unit. NRC’s shall route communications between the BACnet/IP network and the BACnet MS/TP field network. They shall also be responsible for monitoring and controlling their own HVAC equipment such as an air handling unit or boiler. A sufficient number of NRCs shall be supplied to fully meet the requirements of this specification and points indicated on the flow and control diagrams.

2. Each NRC shall be classified as a "native" BACnet device, supporting the BACnet Building Controller (B-BC) profile. Controllers that support a lesser profile such as B-SA are not acceptable. NRCs shall be tested and certified by the BACnet Testing Laboratory (BTL) as Advanced Application Controllers (B-BC).

B. Hardware Specifications:

1. Memory: Both the operating system of the controller, plus the application program for the controller, shall be stored in non-volatile, FLASH memory. Controllers shall contain enough memory for the current application, plus required history logging, plus a minimum of 20% additional free memory.

2. Communication Ports: Each NRC shall provide communication to both the Workstation(s) and the field buses. An on-board 10/100/1000bT Ethernet port shall be provided, as well as a RS-485 port for communications to a maximum of 127 MS/TP devices.

3. Modular Expandability: The system shall employ a modular I/O design to allow easy expansion. Input and output capacity is to be provided through plug-in modules of various types. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.

4. Hardware Override Switches: All digital outputs shall include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. These switches shall be built into the unit and shall provide feedback to the controller so that the position of the override switch can be obtained through software. In addition, each analog output shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position.

5. Local Status Indicator Lamps: Provide as a minimum LED indication of CPU status, Ethernet LAN status, and field bus status. For each output, provide LED indication of the value of the output (On/Off). For each output module provide an LED which gives a visual indication of whether any outputs on the module are manually overridden.

6. Real Time Clock (RTC): Each NRC shall include a battery-backed, real time clock, accurate to 10 seconds per day. The RTC shall provide the following: time of day, day, month, year, and day of week. The system shall automatically correct for daylight savings time and leap years and be Year 2000 compliant.

7. Power Supply: The power supply for the NRCs shall be auto sensing, 24Vac/10-40Vdc power, with a tolerance of +/- 20%. Line voltage below the operating range of the system shall be considered outages. The controller shall contain over voltage surge protection, and require no additional AC power signal conditioning.

8. Automatic Restart After Power Failure: Upon restoration of power after an outage, the NRC shall automatically and without human intervention: update all monitored functions; resume operation based on current, synchronized time and status, and implement special start-up strategies as required.
9. Battery backup: The NRC shall include an on-board battery to back up the controller’s RAM memory. The battery shall provide accumulated backup of all RAM and clock functions for at least 30 days. In the case of a power failure, the NRC shall first try to restart from the RAM memory. If that memory is corrupted or unusable, then the NRC shall restart itself from its application program stored in its FLASH memory.

C. Software Specifications:

1. General. The NRC shall contain FLASH memory to store both the resident operating system AND the application software. There will be no restrictions placed on the type of application programs in the system. Each NRC shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.

2. User Programming Language: The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be English language-based and programmable by the user. The language shall be structured to allow for the easy configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, passwords, and histories. The language shall be self-documenting. Users shall be able to place comments anywhere in the body of a program. Program listings shall be configurable by the user in logical groupings.

D. Control Software:

1. The NRC shall have the ability to perform the following pre-tested control algorithms:
   a. Proportional, Integral plus Derivative Control (PID).
   b. Self Tuning PID.
   c. Two Position Control.
   d. Digital Filter.
   e. Ratio Calculator.
   f. Equipment Cycling Protection.

2. Mathematical Functions: Each controller shall be capable of performing basic mathematical functions (+, -, *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These must be able to be used in the same equations with the mathematical operators and nested up to five parentheses deep.

3. Energy Management Applications: NRCs shall have the ability to perform any or all of the following energy management routines:
   a. Time of Day Scheduling.
   b. Calendar Based Scheduling.
   c. Holiday Scheduling.
   d. Temporary Schedule Overrides.
   e. Optimal Start.
   f. Optimal Stop.
   g. Night Setback Control.
   h. Enthalpy Switchover (Economizer).
   i. Peak Demand Limiting.
   j. Temperature Compensated Duty Cycling.
2.4 STANDALONE DIGITAL CONTROL UNITS (SDCUS)

A. General:

1. Standalone Digital Control Units shall provide control of HVAC, including air handling units, rooftop units, variable air volume boxes, unit ventilators, and other mechanical equipment. Each controller shall be fully programmable, contain its own control programs and will continue to operate in the event of a failure or communication loss to its associated NRC. Each SDCU provided must be a “native” BACnet device, supporting the BACnet Advanced Application Controller (B-AAC) profile. Controllers that support a lesser profile such as B-SA are not acceptable. SDCUs shall be tested and certified by the BACnet Testing Laboratory (BTL) as Advanced Application Controllers (B-AAC).
B. Memory:
   1. Both the operating system of the controller, plus the application program for the controller, shall be stored in non-volatile, FLASH memory. Controllers shall contain enough memory for the current application, plus required history logging, plus a minimum of 20% additional free memory.

C. Communication Ports:
   1. SDCUs shall have a RS-485 communication port to the BACnet MS/TP field bus, operating at a speed of at least 76.8kbps.

D. Input/Output:
   1. Each SDCU shall have enough inputs and outputs to meet the application’s required points. Each SDCU shall support universal inputs, whereas any input may be software-defined as:
      a. Digital Inputs for status/alarm contacts.
      b. Counter Inputs for summing pulses from meters.
      c. Thermistor Inputs for measuring temperatures in space, ducts and thermowells.
      d. Analog inputs for pressure, humidity, flow and position measurements.
   2. SDCU’s must support both digital and analog output types:
      a. Digital Outputs for on/off equipment control.
      b. Analog Outputs for valve and damper position control, and capacity control of primary equipment.

E. Expandability:
   1. For larger controllers (16 base inputs and up), provide input and output expansion through the use of plug-in modules. At least two I/O modules must be capable of being added to the base SDCU.

F. Hardware Override Switches:
   1. All digital outputs on air handling unit controllers shall include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. These switches shall be built into the unit and shall provide feedback to the controller so that the position of the override switch can be obtained through software. In addition, each analog output on air handling unit controllers shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position.

G. Room Sensor Support:
   1. The SDCU shall support a basic room thermistor in plain plastic cover; a room sensor with override and setpoint adjust slider or a sensor with a LCD display.

H. Networking:
   1. Each SDCU will be able to exchange information on a peer to peer basis with other Standalone Digital Control Units, according to the BACnet MS/TP protocol. Each SDCU shall be capable of storing and referencing global variables (on the LAN) with or without any workstations online. Each SDCU shall be able to have its program viewed and/or enabled/disabled through a workstation connected to an NRC.

I. Indicator Lamps:
   1. SDCUs will have as a minimum, LED indication of CPU status, and field bus status.
J. Real Time Clock (RTC):
   1. All SDCUs shall have a real time clock in either hardware or software. The accuracy shall be within 10 seconds per day. The RTC shall provide the following information: time of day, day, month, year, and day of week. Each SDCU shall receive a signal, every hour, over the network from the NRC, which synchronizes all SDCU real time clocks.

K. Automatic Restart After Power Failure:
   1. Upon restoration of power, the SDCU shall automatically and without human intervention, update all monitored functions, resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

L. Battery Back Up:
   1. All SDCUs shall store all programming in non-volatile FLASH memory. All SDCUs except terminal controllers shall include an on-board lithium battery to back up the controller’s RAM memory. The battery shall have a shelf life of over 10 years, and provide accumulated backup of all RAM and clock functions for at least 3 years. In the case of a power failure, the SDCU shall first try to restart from the RAM memory. If that memory is corrupted or unusable, then the SDCU shall restart itself from its application program stored in its FLASH memory.

M. Software – General:
   1. The SDCU shall contain FLASH memory to store both the resident operating system AND the application software. There will be no restrictions placed on the type of application programs in the system. Each SDCU shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.

N. User Programming Language:
   1. The application software shall be user programmable, using the same language as that defined for Network Router/Controllers.
   2. Control Software, Mathematical Functions, and Energy Management Applications must be identical to that which is provided with the Network Router/Controller.

O. History Logging:
   1. Each controller shall be capable of LOCALLY logging any input, output, calculated value or other system variable over user defined time intervals ranging from 1 second to 1440 minutes. Any system can be logged in history. A minimum of 1000 values shall be stored in each log. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logged data shall be downloadable to the Operator Workstation for long term archiving based upon user-defined time intervals, or manual command.

P. Alarm Management:
   1. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms will be tested each scan of the SDCU and can result in the display of one or more alarm messages or reports.
   2. Up to 8 alarms can be configured for each point in the controller.
3. Alarms will be generated based on their priority. A minimum of 255 priority levels shall be provided.

4. If communication with the Operator Workstation is temporarily interrupted, the alarm will be time-stamped and buffered in the controller. When communications return, the alarm will be transmitted to the Operator Workstation if the point is still in the alarm condition.

5. Alarms must be capable of being routed to any BACnet workstation that conforms to the B-OWS device profile and uses the BACnet/IP protocol.

Q. **Air Handler Controllers:**
   1. AHU Controllers shall conform to the BACnet Advanced Application Controller (B-AAC) device profile.
   2. AHU Controllers shall be capable of meeting the requirements of the sequence of operation found in the Execution portion of this specification and for future expansion.
   3. AHU Controllers shall support all the necessary point inputs and outputs as required by the sequence and operate in a standalone fashion.
   4. AHU Controllers shall be fully user programmable to allow for modification of the application software.
   5. A manual override switch shall be provided for all digital and analog outputs on the AHU Controller. The position of the switch shall be monitored in software and available for operator displays and alarm notification.
   6. For each air handler SDCU, provide a local display of at least 4 lines, providing current display of all critical inputs and outputs that the SDCU is controlling. Provide a keypad such that an operator can log on, scroll through point values, and change setpoints that are changeable. The keypad/display must be capable of being mounted either on the controller, or on a control panel door.

R. **VAV Terminal Unit Controllers:**
   1. VAV Controllers shall conform to the BACnet Advanced Application Controller (B-AAC) device profile.
   2. VAV Terminal Unit Controllers shall support, but not be limited to the control of the following configurations of VAV boxes to address current requirements as described in the Sequence of Operation and for future expansion:
      a. Single Duct Cooling Only.
      b. Single Duct Cooling with Reheat (Electric or Hot Water).
      c. Fan Powered (Parallel or Series).
      d. Dual Duct (Constant or Variable Volume).
      e. Supply/Exhaust.
   3. VAV Controllers for single duct applications will come equipped with a built-in actuator for modulation of the air damper. The actuator shall have a minimum torque rating of 35 in.-lb., and contain an override mechanism for manual positioning of the damper during startup and service.
   4. VAV Controllers shall contain an integral velocity sensor accurate to +/- 5% of the full range of the box’s CFM rating.
   5. Each controller shall perform the described Sequence of Operation and have the capability for local time of day scheduling, occupancy mode control, after hour’s operation, alarming, and trending.
   6. VAV Controllers shall be able to communicate with any other Standalone Digital Control Unit on the same MS/TP field bus.
   7. All connections to VAV controllers shall be terminal-plug style. No RJ-45 or other quick-connectors will be allowed.
S. Unitary Controllers:
   1. Unitary Controllers shall conform to the BACnet Advanced Application Controller (B-AAC) device profile.
   2. Unitary Controllers shall support, but not be limited to, the control of the following systems as described in the Sequence of Control and for future expansion:
      a. Heat Pumps (Air to Air, Water to Water).
      b. Packaged Rooftops.
      c. Fan Coils (2 or 4 Pipe).
   3. The I/O of each Unitary Controller shall contain the sufficient quantity and types as required to meet the Sequence of Operation found. In addition, each controller shall have the capability for local time of day scheduling, occupancy mode control, after hour operation, lighting control, alarming, and trending.
   4. Unitary Controllers shall be able to communicate with any other Standalone Digital Control Unit on the same MS/TP field bus.
   5. For all units with manufacturer supplied unitary controllers, the Contractor is responsible for providing hardware and software as required to communicate with the Tier I BAS communication trunk at FMLH.

2.5 BACNET GATEWAY TO THIRD-PARTY DEVICES

A. General:
   1. Where required, provide a BACnet Gateway to interface to non-BACnet systems that use the Modbus protocol, LONworks protocol, or other proprietary protocol. The Gateway shall communicate directly over Ethernet TCP/IP, and shall use the BACnet/IP protocol to communicate with a BACnet Workstation (B-OWS).

B. Communication Ports:
   1. In addition to its on-board Ethernet port, the Gateway shall have at least two serial communications ports for interfaces to third-party systems.

C. Memory:
   1. The Gateway shall have enough RAM memory to store all point configuration data, plus required history logging and alarm buffering. Minimum RAM shall be 8MB. The operating system of the gateway must be stored in FLASH non-volatile memory.

D. User Programming Language:
   1. The Gateway shall employ the same user programmable application software that NRCs and SDCUs use.
   2. Control Software, Mathematical Functions, and Energy Management Applications must be identical to that which is provided with the Network Router/Controller. Gateways that do not have an application programming language will not be accepted.

E. History Logging:
   1. Each Gateway shall be capable of LOCALLY logging any input, output, calculated value or other system variable over user defined time intervals ranging from 1 second to 1440 minutes. Any system can be logged in history. A minimum of 1000 values shall be stored in each log. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logged data shall be downloadable to the Operator Workstation for long term archiving based upon user-defined time intervals, or manual command.
2.6 OPERATOR WORKSTATION REQUIREMENTS

A. General:
1. The operator workstation portion of the BAS shall consist of one or more full-powered configuration and programming workstations, and one or more web-based operator workstations. For this project provide (2) programming workstations and (1) web-based user licenses.
2. The programming and configuration workstation software shall be configurable as either a single workstation system (with a local database) or multi-workstation system where the database is located on a central file server. The client software on multi-workstation system shall access the file server database program via an Ethernet TCP/IP network running at 100MBPS.
3. The web-based user interface software must be capable of expansion up to 100 concurrent users.
4. All workstation software, both programming and software and web-based operator software, shall conform to the BACnet B-OWS device profile, using BACnet/IP to communicate to other BACnet devices.
5. All configuration workstations that meets current standards or operating system that is compatible with controls. The application software shall be capable of communication to all Network Router/Controllers and Standalone Digital Control Units, feature high-resolution color graphics, alarming, reporting, and be user configurable for all data collection and data presentation functions.
6. For multi-workstation systems, a minimum of 256 workstations shall be allowed on the Ethernet network along with the central file server. In this client/server configuration, any changes or additions made from one workstation will automatically appear on all other workstations without the requirement for manual copying of files. Multi-workstation systems with no central database will not be acceptable. Multi-workstation systems with distributed/tiered file servers and a central (master) database will be acceptable.

B. Administration and Programming Workstation Software:
1. General Description:
   a. The software architecture must be object-oriented in design, a true 32-bit application suite utilizing Microsoft’s OLE, COM, DCOM and ODBC technologies. These technologies make it easy to fully utilize the power of the operating system to share, among applications (and therefore to the users of those applications), the wealth of data available from the BAS.
   b. The workstation functions shall include monitoring and programming of all DDC controllers. Monitoring consists of alarming, reporting, graphic displays, long term data storage, automatic data collection, and operator-initiated control actions such as schedule and setpoint adjustments.
   c. Programming of controllers shall be capable of being done either off-line or on-line from any operator workstation. All information will be available in graphic or text displays. Graphic displays will feature animation effects to enhance the presentation of the data, to alert operators of problems, and to facilitate location of information throughout the DDC system. All operator functions shall be selectable through a mouse.
2. System Database:
a. The files server database engine must be Microsoft SQL Server, or another ODBC-compliant, relational database program. This ODBC (Open Database Connectivity)-compliant database engine allows for an owner to write custom applications and/or reports which communicate directly with the database avoiding data transfer routines to update other applications. The system database shall contain all point configurations and programs in each of the controllers that have been assigned to the network. In addition, the database will contain all workstation files including color graphic, alarm reports, text reports, historical data logs, schedules, and polling records.

3. User Interface:
   a. The BAS workstation software shall allow the creation of a custom, browser-style interface linked to the user that has logged into the workstation software. This interface shall support the creation of "hot-spots" that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software. Furthermore, this interface must be able to be configured to become a user's "PC Desktop" – with all the links that a user needs to run other applications. This, along with the Microsoft Windows user security capabilities, will enable a system administrator to setup workstation accounts that not only limit the capabilities of the user within the BAS software but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shutdown the active alarm viewer and/or unable to load software onto the PC.

4. User Security:
   a. The software shall be designed so that each user of the software can have a unique username and password. This username/password combination shall be linked to a set of capabilities within the software, set by and editable only by, a system administrator. The sets of capabilities shall range from View only, Acknowledge alarms, Enable/disable and change values, Program, and Administer. The system shall allow the above capabilities to be applied independently to each and every class of object in the system. The system must allow a minimum of 256 users to be configured per workstation. There shall be an inactivity timer adjustable in software that automatically logs off the current operator after the timer has expired.

5. Configuration Interface:
   a. The workstation software shall use a familiar Windows Explorer™-style interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a "network map" of all controllers and their associated points, programs, graphics, alarms, and reports in an easy to understand structure. All object names shall be alphanumeric and use Windows long filename conventions.
b. The configuration interface shall also include support for template objects. These template objects shall be used as building blocks for the creation of the BAS database. The types of template objects supported shall include all data point types (input, output, string variables, setpoints, etc.), alarm algorithms, alarm notification objects, reports, graphics displays, schedules, and programs. Groups of template object types shall be able to be set up as template subsystems and systems. The template system shall prompt for data entry if necessary. The template system shall maintain a link to all "child" objects created by each template. If a user wishes to make a change to a template object, the software shall ask the user if he/she wants to update all of the child objects with the change. This template system shall facilitate configuration and programming consistency and afford the user a fast and simple method to make global changes to the BAS.

C. Color Graphic Displays:
   1. Create user defined, color graphic displays for the viewing of all mechanical and building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition, operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse. Requirements of the color graphic subsystem include:
      a. SVGA, bit-mapped displays. The user shall have the ability to import AutoCAD generated picture files as background displays.
      b. A built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, ad graphs which can be "dropped" on a graphic through the use of a software configuration "wizard." These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels. Using the mouse, operators shall be able to adjust setpoints, start or stop equipment, modify PID loop parameters, or change schedules.
      c. Status changes or alarm conditions must be able to be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.
      d. Ability to link graphic displays through user defined objects, alarm testing, or the result of a mathematical expression. Operators must be able to change from one graphic to another by selecting an object with a mouse - no menus will be required.
      e. If separate, provide a copy of the full graphic editing software on each workstation.

D. Automatic Monitoring:
   1. The software shall allow for the automatic collection of data and reports from any controller through either a hardwire or modem communication link. The frequency of data collection shall be completely user-configurable.

E. Alarm Management:
   1. The software shall be capable of accepting alarms directly from controllers, or generating alarms based on evaluation of data in controllers and comparing to limits or conditional equations configured through the software. Any alarm (regardless of its origination) will be integrated into the overall alarm management system and will appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphics, or reports.
   2. Alarm management features shall include:
a. A minimum of 255 alarm notification levels. Each notification level will establish a unique set of parameters for controlling alarm display, acknowledgment, keyboard annunciation, alarm printout and record keeping.

b. Automatic logging in the database of the alarm message, point name, point value, connected controller, timestamp, username and time of acknowledgement, username and time of alarm silence (soft acknowledgement).

c. Automatic printing of the alarm information or alarm report to an alarm printer or report printer.

d. Playing an audible beep or audio (wav) file on alarm initiation or return to normal.

e. Sending an email or alphanumeric page to anyone listed in a workstation’s email account address list on either the initial occurrence of an alarm and/or if the alarm is repeated because an operator has not acknowledged the alarm within a user-configurable timeframe. The ability to utilize email and alphanumeric paging of alarms shall be a standard feature of the software integrated with the operating system’s mail application interface (MAPI). No special software interfaces shall be required.

f. Individual alarms shall be able to be re-routed to a workstation or workstations at user-specified times and dates. For example, a critical high temp alarm can be configured to be routed to a Facilities Dept. workstation during normal working hours (7am-6pm, Mon-Fri) and to a Central Alarming workstation at all other times.

g. An active alarm viewer shall be included which can be customized for each user or user type to hide or display any alarm attributes.

h. The font type and color, and background color for each alarm notification level as seen in the active alarm viewer shall be customizable to allow easy identification of certain alarm types or alarm states.

i. The active alarm viewer can be configured such that an operator must type in text in an alarm entry and/or pick from a drop-down list of user actions for certain alarms. This ensures accountability (audit trail) for the response to critical alarms.

F. Custom Report Generation:

1. The software will contain a built-in custom report generator, featuring word processing tools for the creation of custom reports. These custom reports shall be able to be set up to automatically run or be generated on demand. Each workstation shall be able to associate reports with any word processing or spreadsheet program loaded on the machine. When the report is displayed, it will automatically spawn the associated report editor such as MS Word™.

a. Reports can be of any length and contain any point attributes from any controller on the network.

b. The report generator will have access to the user programming language in order to perform mathematical calculations inside the body of the report, control the display output of the report, or prompt the user for additional information needed by the report.

c. It shall be possible to run other executable programs whenever a report is initiated.

d. Report Generator activity can be tied to the alarm management system, so that any of the configured reports can be displayed in response to an alarm condition.

e. Standard reports shall include:

1) Points in each controller.
2) Points in alarm.
3) Disabled points.
4) Overridden points.
5) Operator activity report.
6) Alarm history log.
7) Program listing by controller with status.
8) Network status of each controller.

G. Spreadsheet-Style Reports:
   1. The software shall allow the simple configuration of row/column (spreadsheet-style) reports on any class of object in the system. These reports shall be user-configurable and shall be able to extract live (controller) data and/or data from the database. The user shall be able to set up each report to display in any text font, color and background color. In addition, the report shall be able to be configured to filter data, sort data and highlight data which meets user-defined criteria.

H. HTML Reporting:
   1. The above spreadsheet-style reports shall be able to be run to an HTML template file. This feature will create an HTML "results" file in the directory of the HTML template. This directory can be shared with other computer users, which will allow those users with access to the directory to "point" their web browser at the file and view the report.

I. Scheduling:
   1. It shall be possible to configure and download from the workstation schedules for any of the controllers on the network.
      a. Time of day schedules shall be in a calendar style and shall be programmable for a minimum of one year in advance. Each standard day of the week and user-defined day types shall be able to be associated with a color so that when the schedule is viewed it is very easy, at-a-glance, to determine the schedule for a particular day even from the yearly view. To change the schedule for a particular day, a user shall simply click on the day and then click on the day type.
      b. Each schedule will appear on the screen viewable as the entire year, monthly, week and day. A simple mouse click shall allow switching between views. It shall also be possible to scroll from one month to the next and view or alter any of the schedule times.
      c. Schedules will be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation will be automatically updated to the corresponding schedule in the controller.

J. Programmer's Environment:
   1. The programmer's environment will include access to a superset of the same programming language supported in the controllers. Here the programmer will be able to configure application software off-line (if desired) for custom program development, write global control programs, system reports, wide area networking data collection routines, and custom alarm management software. On the same screen as the program editor, the programming environment shall include dockable debug and watch bars for program debugging and viewing updated values and point attributes during programming. In addition, a wizard tool shall be available for loading programs from a library file in the program editor.

K. Saving/Reloading:
The workstation software shall have an application to save and restore field controller memory files. This application shall not be limited to saving and reloading an entire controller – it must also be able to save/reload individual objects in the controller. This allows off-line debugging of control programs, for example, and then reloading of just the modified information.

L. Data Logging:

1. The workstation software shall have the capability to easily configure groups of data points with trend logs and display the trend log data. A group of data points shall be created by drag-and-drop method of the points into a folder. The trend log data shall be displayed through a simple menu selection, or from a hot spot on a graphic display. This data shall be able to be saved to file and/or printed.

M. Audit Trail:

1. The workstation software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.

N. Fault Tolerant File Server Operation:

1. The system shall provide the option to provide fault tolerant operation in the event of the loss of the CPU, disk drives, or other hardware required to maintain the operational integrity of the system. Operational integrity includes all user interfaces, monitoring of alarm points and access points, and executing access control functions.

The switchover mechanism provided shall be automatic. Should the failure be caused by hardware, then the system shall immediately switch to the Backup computer. Should the system failure be caused by software (instruction or data), the system shall not pass the faulted code to the Backup computer, otherwise the Backup shall fail in the same manner of the Primary computer.

2. Switchover to the Backup computer shall be initiated and effective (complete) in a manner and time frame that precludes the loss of event data, and shall be transparent to the system users, except for an advisory alarm message indicating that the switchover has occurred.

3. When the system fails-over from the Primary to the Backup computer, no alarm or other event shall be lost, and the Backup computer shall take control of all system functions.

4. A single component failure in the system shall not cause the entire system to fail. All system users shall be informed of any detectable component failure via an alarm event. System users shall not be logged off as a result of a system failure or switchover.

5. The Primary computer shall provide continual indication that the Backup computer is unavailable until such time that the fault has been purged.

O. Web-Based Operator Software:

1. Day-to-day operation of the system shall be accessible through a standard web browser interface, allowing technicians and operators to view any part of the system from anywhere on the network. Access to the system must be available from a dial-in connection over the Internet.

P. Graphic Displays:

1. The browser-based interface must share the same graphical displays as the Administration and Programming Workstations, presenting dynamic data on site layouts, floor plans, and equipment graphics. The browser's graphics shall support commands to change setpoints, enable/disable equipment and start/stop equipment.
2. Through the browser interface, operators must be able to navigate through the entire system, and change the value or status of any point in any controller. Changes are effective immediately to the controller, with a copy stored in the system database.

Q. Alarm Management:
   1. Through the browser interface, a live alarm viewer identical to the alarm viewer on the Administration and Programming workstation shall be presented, if the user’s password allows it. Users must be able to receive alarms, silence alarms, and acknowledge alarms through a browser. If desired, specific operator text must be able to be added to the alarm record before acknowledgement.

R. Groups and Schedules:
   1. Through the browser interface, operators must be able to view pre-defined groups of points, with their values updated automatically.
   2. Through the browser interface, operators must be able to change schedules – change start and stop times, and add new times to a schedule.

S. User Accounts and Audit Trail:
   1. The same user accounts shall be used for the browser interface and for the operator workstations. Operators must not be forced to memorize multiple passwords.
   2. All commands and user activity through the browser interface shall be recorded in the system’s activity log, which can be later searched and retrieved by user, date, or both.

T. History Logging:
   1. The OWS shall be capable of logging any input, output, calculated value or other system variable to/from local controllers over user defined time intervals ranging from 1 second to 1440 minutes, with default histories set up at 5-minute intervals. Any system can be logged in history and all control points shall have histories enabled. A minimum of 1 year of values shall be stored in each log. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logged data shall be downloadable from the Operator Workstation in spreadsheet format.

2.7 INPUT/OUTPUT INTERFACE
   A. Provide instrumentation as required for monitoring, control or optimization functions.
   B. Hardwired inputs and outputs may tie into the system through NRC’s or SDCU’s.
   C. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.
   D. Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
   E. Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.
   F. Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with – and field configurable to – commonly available sensing devices.

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G. Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.

H. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC or a 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable potentiometer for manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.

I. Tri-State Outputs: Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation etc.). Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

J. Input/Output points shall be the universal type, i.e., controller input or output may be designated (in software) as either a binary or analog type point with appropriate properties. Application specific controllers are exempted from this requirement.

K. System Object Capacity. The system size shall be expandable to at least twice the number of input/output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

2.8 POWER SUPPLIES AND LINE FILTERING

A. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish overcurrent protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

   1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.
      a. Unit shall operate between 0 deg. C and 50 deg. C (32 deg F and 120 deg F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MIL STD 810C for shock and vibration.
      b. Line voltage units shall be UL recognized and CSA approved.

B. Power Line Filtering:

   1. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge protection shall have the following at a minimum:
      a. Dielectric strength of 1000 volts minimum.
      b. Response time of 10 nanoseconds or less.
      c. Transverse mode noise attenuation of 65 dB or greater.
      d. Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz.
2.9 AUXILIARY CONTROL DEVICES

A. Motorized control dampers, unless otherwise specified elsewhere, shall be as follows:

1. Size dampers so that when wide open the pressure drop is a sufficient amount of its close off pressure drop to shift the characteristics curve to near linear.
2. Control dampers shall be the parallel or opposed blade type.
   a. Outdoor and/or return air mixing dampers and face and bypass (F&BP) dampers shall be parallel blade, arranged to direct airstreams toward each other.
   b. Other modulating dampers shall be the opposed blade type.
   c. Two-position shutoff dampers shall be opposed blade type with blade and side seals.
3. Damper frames shall be 13 gauge galvanized or stainless steel channel or 1/8 inch extruded aluminum with reinforced corner bracing.
4. Damper blades shall not exceed 6 inches in width or 48 inches in length. Blades are to be suitable for medium velocity performance (2000 fpm). Blades shall be not less than 14 gauge.
5. Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze, or better.
6. All blade edges and top, bottom and sides of the frame shall be provided with replaceable butyl rubber or neoprene seals. The blade seals shall provide for a maximum leakage rate of 5 cfm per ft² at 5 in. w.g. differential pressure. Provide air foil blades suitable for a wide-open face velocity of 1500 fpm.
7. Individual damper sections shall not be wider than 48 inches. The maximum individual damper area shall not exceed 20 square feet. Provide a minimum of one damper actuator per section.
8. Damppers shall have exposed linkages.
9. Dampers shall be Ruskin Model CD-60, Greenheck Model VCD-33 or Tamco Series 9000.

B. Electric Damper/Valve Actuators:

1. The actuator shall have mechanical or electronic stall protection to prevent damage to the actuator throughout the rotation of the actuator.
2. For power-failure/safety applications, an internal mechanical, spring-return mechanism shall be built into the actuator housing. Arrange spring return, fail-safe at either the normally open or normally closed position in the event of power failure, control failure, fire or freeze-up protection as indicated on the Drawings.
3. Proportional actuators shall accept a 0 to 10 VDC control signal and provide a 2 to 10 VDC operating range.
4. All 24 VAC/VDC actuators shall operate on Class 2 wiring.
5. No line voltage dampers will be accepted.
6. All non-spring-return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring-return actuators with more than 7 Nm (60 in.-lb) torque capacity shall have a manual crank for this purpose.
7. Size for torque required for damper seal at maximum design conditions and valve close-off pressure for system design.
8. Coupling: U-bolt dual nut clamp with a V-shaped, toothed cradle; directly couple and mount to the valve bonnet stem; or ISO-style direct-coupled mounting pad.
9. Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
10. Overload protected electronically throughout rotation.
12. Agency Listings: ISO 9001, cULus, CE or CSA
13. Manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
14. Manufacturer: Belimo.

C. Control Valves:
1. Control valves shall be two-way or three-way type for two-position or modulating service as shown.
2. Manufacturer: Belimo or as approved by Owner.
3. Provide position indicators.
4. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:
   a. Water Valves:
      1) Two-way: 150% of total system (pump) head.
      2) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.
      3) Steam Valves: 150% of operating (inlet) pressure.
5. Valves shall be designed to modulate with up to 50 psi pressure differential across the valve.
6. Water and Steam Valves:
   a. Sizing Criteria:
      1) Select two-way valves for liquids to have equal percentage characteristics. Select three-way valves for liquids to have linear characteristics.
      2) Maximum 10 feet water pressure drop.
   b. Valves 1/2 in. through 2 in. shall be bronze body or cast brass ANSI Class 250, with stainless steel trim spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have stainless steel ball. Minimum Cv to be 4.7.
   c. Valves 2-1/2 in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing, stainless steel trim.
7. Fail Safe Positions: Control valves NPS 2-1/2 inch and larger installed in steam and chilled water piping shall be provided with spring-return actuators.
   a. Chilled Water valves shall fail closed.
   b. Steam valves serving steam to hot water convertors shall fail closed.
   c. Steam valves serving air handler heating coils shall fail open.

D. Pressure Independent Control Valves
1. NPS 2-inch and Smaller: Forged brass body rated at no less than 250 PSI, stainless steel ball and stem, female NPT union ends, dual EPDM lubricated O-rings and a brass or TEFZEL characterizing disc.
2. NPS 2-1/2 through 6-inch: GG25 cast iron body according to ANSI Class 125, standard class B, stainless steel ball and blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring packing design, PTFE seats, and a stainless steel flow characterizing disc.
3. Accuracy: The control valves shall accurately control the flow from 0 to 100% rated flow with an operating pressure differential range of 5 to 50 PSI differential across the valve with a valve body flow accuracy of +/- 5% total assembly error incorporating differential pressure fluctuation, manufacturing tolerances and valve hysteresis.


5. All actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow. Programming using actuator mounted switches or multi-turn actuators are not acceptable.

6. Where indicated on the plans, the valve shall provide water coil optimization and shall be accomplished by utilizing a pressure independent control valve assembly; two temperature sensors providing feedback of coil inlet and outlet water temperatures; and an electronic flow meter to provide analog flow feedback. Software shall control the valve to avoid the coil differential temperature from falling below a programmed set point, The valve assembly shall be capable of accepting an analog signal representing the coil power required. Real-time data and configuration of valve operating parameters shall be available by means of BACnet MS/TP, BACnet/IP or HTTP. Monitored points shall include, but not be limited to inlet and outlet coil water temperatures, absolute flow, absolute valve position, absolute coil power and total heating/cooling energy in BTU/hr. Configuration points shall include but not be limited to valve, flow, and power settings. Historical trend data shall be stored for up to 13 months and be retrievable in a standard time-stamped format.

7. The manufacturer shall provide a published commissioning procedure following the guidelines of the National Environmental Balancing Bureau (NEBB) and the Testing Adjusting Balancing Bureau (TABB).

8. A wet calibrated electronic flow meter shall provide dynamic feedback to measure flow and verify performance.

9. The control valve shall require no maintenance and shall not include replaceable cartridges.

E. Binary Temperature Devices:

1. Low-voltage space thermostat shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment 13 deg. C to 30 deg. C (55 deg. F to 85 deg. F) set point range, 1 deg C (2 deg F) maximum differential and vented ABS plastic cover.

2. Line-voltage space thermostat shall be bimetal-actuated, open contact type, or bellows-actuated, enclosed, snap-switch type of equivalent solid-state type, with heat anticipator, UL listed for electrical rating, concealed setpoint adjustment, 13 deg. C to 30 deg. C (55 deg F to 85 deg. F) setpoint range, 1 deg C (2 deg F) maximum differential, and vented ABS plastic cover.

3. Low-limit thermostats. Low-limit airstream thermostats shall be UL listed, vapor pressure type, with an element of 6 m (20 ft) minimum length. Element shall respond to the lowest temperature sensed by an 30 cm (1 ft) section. The low-limit thermostat shall be manual reset only.

F. Temperature Sensors:

1. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor type. Room sensors shall be +/- 1% accuracy with setpoint adjustment.

2. Duct sensors shall be single point or averaging as shown, +/- 0.5% accuracy or +/- -0.25% as required by the application. Averaging sensors shall be a minimum of 5 ft in length per 10 ft² of duct cross section.
3. Immersion sensors shall be provided with a separable stainless steel well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed. The well must withstand the flow velocities in the pipe.
4. Non-Public Spaces and Patient Care areas: Space sensors shall be equipped with set point adjustment, override digital switch, LCD display, and communication port. Use tamperproof screws to mount covers.
5. Common areas: Space sensors shall be equipped with communication port. The device shall not be provided with override control, adjustment knob or display. Use tamperproof screws to mount covers.
6. Where Indicated on Drawings or areas subject to vandalism: Space sensors shall be a vandal-proof stainless steel plate, recess mounted with tamperproof screws. No setpoint adjustment.
7. Provide matched temperature sensors for differential temperature measurement.
8. Temperature sensors shall be provided free of manufacturer identification labels or stamps.
9. Provide nickel sensors with a 0-10V signal.

G. Combination CO₂/Temperature Sensor:
1. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor type. Room sensors shall be +/- 1% accuracy with setpoint adjustment. CO₂ sensor shall measure via infra-red. Provide nickel sensors with a 0-10V signal.
2. Measuring range shall be 0 to 2000 ppm.
3. Accuracy: +/- 50 ppm.
4. Calibration: Calibration free for eight years.

H. Humidity Sensors:
1. Room sensors shall have a sensing range of 20% to 80%. Duct sensors shall have a sensing range of 10% to 90%.
2. Duct sensors shall be provided with a sampling chamber and have +/- 3% accuracy.
3. Outdoor air humidity sensors shall have a sensing range of 20% to 95% RH. They shall be suitable for ambient conditions of 32 deg. F to 170 deg. F.
4. Humidity sensor’s drift shall not exceed 1% of full scale per year.

I. Flow Switches:
1. Flow-proving switches shall be differential pressure type.
2. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as specified.

J. Relays:
1. Control relays shall be UL listed plug-in type with dust cover and LED "energized" indicator. Contact rating, configurations, and coil voltage shall be suitable for application.
2. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable +/- 200% (minimum) from set point shown on plans. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

K. Override Timers:
1. Override timers shall be spring-would line voltage, UL Listed, with contact rating and configuration as required by application. Provide 0-to-6-hour calibrated dial unless otherwise specified. Timer shall be suitable for flush mounting on control panel face and located on local control panels or where shown.
L. Current Transmitters:
   1. AC current transmitters shall be the self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A full scale, with internal zero and span adjustment and +/- 1% full-scale accuracy at 500 ohm maximum burden.
   2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA Recognized
   3. Unit shall be split-core type for clamp-on installation on existing wiring.

M. Current Transformers:
   1. AC current transformers shall be UL/CSA Recognized and completely encased (except for terminals) in approved plastic materials.
   2. Transformers shall be available in various current ratios and shall be selected for +/- 1% accuracy at 5 A full-scale output.
   3. Transformers shall be fixed-core or split-core type for installation on new or existing wiring, respectively.

N. Voltage Transmitters:
   1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4 to 20 mA output with zero and span adjustment.
   2. Ranges shall include 100 to 130 VAC, 200 to 250 VAC, 250 to 330 VAC, and 400 to 600 VAC full-scale, adjustable, with +/- 1% full-scale accuracy with 500 ohm maximum burden.
   3. Transmitters shall be UL/CSA Recognized at 600 VAC rating and meet or exceed ANSI/ISA S50.1 requirements.

O. Voltage Transformers:
   1. AC voltage transformers shall be UL/CSA Recognized, 600 VAC rated, complete with built-in fuse protection.
   2. Transformers shall be suitable for ambient temperatures of 4 deg. C to 55 deg. C (40 deg. F to 130 deg. F) and shall provide +/- .5% accuracy at 24 VAC and a 5 VA load.
   3. Windings (except for terminals) shall be completely enclosed with metal or plastic material.

P. Power Monitors:
   1. Power monitors shall be the three-phase type furnished with three-phase disconnect/shorting switch assembly, UL Listed voltage transformers, and UL Listed split-core current transformers.
   2. They shall provide a selectable rate pulse output for kWh reading and a 4 to 20 mA output for kW reading. They shall operate with 5 A current inputs with a maximum error of +/- 2% at 1.0 power factor or +/- 2.5% at 0.5 power factor.

Q. Current Switches:
   1. Current-operated switches shall be self-powered, split-core, solid-state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.
   2. When used for pump or fan status, differentiate signal between off, on with no load, and on with load
R. Water Pressure Transducers:
   1. Transducer shall have linear output signal. Zero and span shall be field adjustable.
   2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.
   3. Water pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and block and bleed valves.
   4. Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over range limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and five-valve manifold.

S. Differential Pressure Type Switches (Air Or Water Service):
   1. Switches shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as shown.

T. Static Pressure Transmitters:
   1. The sensors shall be a variable capacitance type, utilizing a stainless steel diaphragm and insulated electrode for position of the diagram. Provide isolation and bypass hand valves.
   2. The sensor shall produce a linear 4 to 20 mA with accuracies of 1% full scale in normal ambient temperature environments.
   3. Pressure ranges 0 to 0.1 w.g through 0 to 25.0 in w.g.
   4. The transmitter shall be temperature compensated to account for any error over the entire temperature range of 40 degrees F to 100 degrees F to 95% RH. Over-pressureization 10 inches w.g. or up to ten times range.
   5. Transmitter shall be equal to Seta Model C264.

U. Local Control Panels:
   1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.
   2. Interconnections between internal and face-mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/interlock drawings, with adequate clearance or field wiring. Control terminations for field connection shall be individually identified per control drawings.
   3. Provide On/OFF power switch with overcurrent protection for control power sources to each local panel.
2.10 ROOM PRESSURE MONITORING SYSTEMS

A. Systems to be equal to TSI, Inc. Model 8636 SUREFLOW Room Pressure Monitoring System. The system shall continuously measure, display and output (to the DDC system) the room pressure to meet the recommendations set forth in the Centers for Disease Control and Prevention's "Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health Care Facilities" 1994, Supplement 3: Engineering Controls. System to consist of: through-wall pressure sensor (constant temperature thermal anemometer type); connector cable between sensor and monitor; wall-mounted room pressure monitor panel (with indicator lights, alphanumeric digital display indicating room pressure in inches of water, audible alarm, analog pressure output and alarm output to DDC system); Transformer. The Contractor shall confirm unit communication protocol prior to ordering.

B. In addition to the room pressure monitors described above provide an additional visual monitor as manufactured by Lamiflow Technologies, LLC. Unit shall be equal to the Lamiflow Monitor models LN-102F, LP-102F, LN-102FS, or LP-102FS depending on site conditions. Device shall be unpowered and monitor airflow from one area to another. Models shall be accurate to +/-5% of full scale to 100 FPM, and +/-10% from 100 FPM to top of scale. Scales shall be easy to read and visible from both sides. Standard size single models shall be 4” tall by 1.75” wide and extend from 4” to 7”.

2.11 WIRING AND RACEWAYS

A. General: Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Divisions 26 and 27.

B. All insulated wire to be copper conductors, UL labeled for 90 deg. C minimum service.

2.12 FIBER OPTIC CABLE SYSTEM

A. Optical Cable: Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. The sheath shall be UL Listed OFNP in accordance with NEC Article 770. The optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125mm.

B. Connectors: All optical fibers shall be field-terminated with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

2.13 PNEUMATIC CONTROLS

A. General: Provide complete system of pneumatic controls to supplement the electronic/electric control system as indicated on the drawings and specified below.

B. Pneumatic Actuators:

1. Size pneumatic actuators to operate their appropriate dampers or valves with sufficient reserve power to provide smooth modulating action or 2-position action as specified. When so specified in sequence of operation, where more than 2 actuators are to be operated in sequence to each other, provide position feedback positive positioners with adjustable startpoint and operating range.

   a. Install pneumatic actuators on all valves 1-1/2 inch and larger.

   b. Install pneumatic actuators on all multi-blade control dampers not part of life safety system.
C. Pneumatic Air Piping:

1. Seamless copper tubing: Type K or L, ASTM B 88; with cast-bronze solder joint fittings, ANSI B16.18; or wrought-copper solder-joint fittings, ANSI B16.22; except brass compression-type fittings at connections to equipment.
   a. Install 1/2 inch minimum copper tubing from air compressor to central control cabinets.

2. Virgin polyethylene non-metallic tubing: ASTM D 2737, and with flame-retardant harness for multiple tubing. Use compression or push-on polyethylene fittings.

D. Pneumatic Air Piping Installation:

1. Installation: Accessible tubing is defined as that tubing run in mechanical equipment rooms; inside mechanical equipment enclosures, such as heating and cooling units, instrument panels etc; or above suspended ceilings with easy access. Inaccessible tubing is defined as tubing run in concrete slabs, walls or ceilings with no access.
   a. Provide copper tubing with maximum unsupported length of 3 feet- 0 inch, for accessible tubing run exposed to view. Polyethylene tubing may be used in lieu of above, when run within adequately supported, rigid enclosure, such as metallic raceways or EMT. Terminal single-line connections less than 18 inch in length may be copper tubing, or polyethylene tubing run inside flexible steel protection. Accessible tubing run in concealed locations, such as above suspended ceilings with easy access, etc. maybe copper or polyethylene bundled and sheathed tubing.
   b. Install accessible tubing below 8 feet above finished floor in rigid metallic conduit.
   c. Provide copper or polyethylene tubing for inaccessible areas, other than in concrete pour. If polyethylene tubing is used, install in EMT or use vinyl-jacketed polyethylene tubing.
   d. Provide copper or polyethylene tubing when installed in concrete pour. If copper is used, protect at floor line with EMT extending 6 inch above floor and 6 inch into pour. Pressure test before and after pour for leak and pinch. If polyethylene is used, provide EMT conduit in pour and extend 6 inch above floor line; pull tubing through conduit after pour.
   e. Pressure test control air piping at 30 psi for 24 hours. Test fails if more than 5 psi
   f. Fasten flexible connections bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support tubing neatly.
   g. Number-code or color-code tubing, except local individual room control tubing, for future identification and servicing of control system.
   h. Leave a minimum of two spares in bundled plastic tubing.
   i. Do not attach rigid air piping, raceways, etc. to air moving equipment.

PART 3 - EXECUTION

3.1 SECTION INCLUDES

A. Examination.
B. Protection.
C. Coordination.
D. General Workmanship.
E. Field Quality Control.
F. Existing Equipment.
G. Wiring.
H. Communication Wiring.
I. Fiber Optic Cable.
J. Installation of Sensors.
K. Flow Switch Installation.
L. Actuators.
M. Warning Labels.
N. Identification of Hardware and Wiring.
O. Controllers.
P. Programming.
Q. Control System Checkout and Testing.
R. Control System Demonstration and Acceptance.
S. Cleaning.
T. Training.

3.2 EXAMINATION
A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/Engineer for resolution before rough-in work is started.
B. The Contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the Engineer for resolution before rough-in work is started.
C. The Contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the Contractor's work and the plans and the work of others—the Contractor shall report these discrepancies to the Engineer and shall obtain written instructions for any changes necessary to accommodate the Contractor's work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the Contractor to report such discrepancies shall be made by – and at the expense of – this Contractor.

3.3 PROTECTION
A. The Contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.
B. The Contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The Contractor shall protect any material that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.
3.4 COORDINATION

A. Site:
   1. Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the Contractor shall assist the working out space conditions to make a satisfactory adjustment. If the Contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the Contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
   2. Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.

B. Submittals. Refer to the "Submittals" article in Part 1 of this specification for requirements.

C. Test and Balance:
   1. The Contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
   2. The Contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
   3. In addition, the Contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
   4. The tools used during the test and balance process will be returned at the completion of the testing and balancing.

D. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the Contractor as follows:
   1. All communication media and equipment shall be provided as specified in Part 2, "Communication" of this specification.
   2. Each supplier of a controls product is responsible for the configuration, programming, startup and testing of that product to meet the sequences of operation described in this section.
   3. The Contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of the specification.
   4. The Contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
   5. The Contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.5 POINT NAMING CONVENTION

A. Point naming convention shall be consistent within the building. For example, if using supply air temperature, supply air temperature shall be used throughout the building. Do not use discharge air temperature on one unit and supply air temperature on another piece of equipment. Coordinate with existing equipment and Froedtert staff prior to starting point naming convention.

B. Point names shall be separated by “-” or “.” and shall not contain “_” or “/”
C. Equipment naming shall use naming convention found on the Contract Documents unless specified and approved differently by Froedtert Health.

D. Within the same building the use of previous naming conventions is acceptable and shall be coordinated with Froedtert Health.

3.6 GENERAL WORKMANSHIP

A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electrical Code (NEC).

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.7 GENERAL PROGRAMMING AND ALARM STANDARDS

A. Units, display digits, and change of value standards shall be used for displaying values in graphics.

1. Value of 0.1 shall be used for all readings with the following exceptions:
   a. Air Pressure readings shall use a value of 0.01 for all air handler static pressure readings.
   b. TSI room pressure readings shall use a value of 0.001.

B. Alarm messages shall be programmed to include the following at a minimum and format shall be reviewed with Froedtert Staff:

   1. Building ID
   2. Equipment ID
   3. Brief Description of Alarm
   4. Values of point causing alarm
   5. Timestamp included along with alarm message file.

C. Alarm messaging shall be capable of being notified out to Froedtert staff via pager, text message, or email format. Controls vendor shall coordinate with Froedtert staff during implementation to properly assign alarm messages to designated personnel. Owner training sessions shall be used to validate critical alarm messaging is properly set-up.

D. Critical Alarms are to be reviewed during the implementation phase with the Froedtert staff and examples of critical equipment or areas are Surgery AHU's, Operating Room Equipment, HVAC equipment serving Labs, hazardous gases, etc.

E. Alarm Classifications shall be classified as either Tier 1 or Tier 2 and coordinated with Froedtert Staff. The following is additional information regarding alarming for each Alarm Class:

   1. Tier 1 Alarm Class
      a. Alarm Routing – Pager, Console
      b. Time Delays – Delay Values shall be determined and coordinated with Froedtert Health

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2. Tier 2 Alarm Class
   a. Alarm Routing – Pager, Console
   b. Time Delays – Delay Values shall be determined and coordinated with Froedtert Health
   c. Recurring Alarm Delays – 5 minutes. Recurring alarm shall be continuously sent out per the delay period until alarm is addressed by staff.
   d. Time Delay to Notify Supervisor – 60 minutes.

3.8 TRENDING STANDARDS
   A. All trends shall be instantaneous trends and not averaging.
   B. Coordinate with Froedtert Health all equipment which shall be identified as “Critical”
   C. Only trends for critical spaces (patient rooms, sterile storage, Operating Rooms, Laboratories, etc.) shall be set-up for long term storage. All other point trends shall follow 24 hours of storage time or a storage limit of 20 for Change of Value (COV) trends.
   D. Trend interval shall be every 10 minutes or change of value.

3.9 GRAPHIC STANDARDS
   A. As a part of the submittal process provide a sample graphic of graphics which will be provided. Sample graphic shall be project specific.
   B. The following shall be a hierarchy of the graphics provided.
      1. Campus Level Home Screen:
         a. Indicate campus level graphic layout of all buildings accessible on the Building Automation System (2D or 3D representative layout).
         b. Provide clickable links on each building to access respective building graphic screens.
         c. Provide ability to link other Froedtert Health campuses to this Home Screen.
      2. Individual Building Home Screen:
         a. Water Side Plant Equipment Summary – Boilers, chillers, Heat Exchangers, convertors, Central Utility Plant service metering, etc.
         b. Air Handling Unit (AHU) Summary – AHU status table including valve positions, AHU temperatures, damper positions, fan speeds, etc.
         c. General Floor Layout – Include a summary screen of floor plan with graphic links for each floor or list of floors with linked button to detailed floor plan.
         d. Detailed Floor Plan Graphics
            1) Dynamic color-coded space temperature readouts
            2) Occupancy Status (where applicable)
            3) Link to VAV/terminal unit graphics
         e. Detailed Meter Graphics
         f. Other Graphics
            1) Floor Monitoring Graphics
            2) Isolation Room Space Pressure Monitoring
3) Room Temperature and Humidity Monitoring (Surgery, ED, GI, Cath, etc.)
4) Misc. Equipment.

C. All point descriptions on graphics shall be abbreviated capital letters.

D. All graphic page wording shall be readable when viewed on a standard single pane view without zooming in.

E. The color for all alarms shall be Red.

F. Background color of values of points shall be coordinated with Froedtert Health.

G. All graphic pages for each BAS platform shall have standard information shown across the top of each graphic.

H. The following information shall be included in the Main Header of a page at a minimum:
   1. Back Button
   2. Froedtert Health Logo
   3. Campus/Building Name
   4. Graphic Page Description and Sub Description (if necessary)
   5. Current Weather and Outside Air Conditions (temp, %RH)
   6. Current Time and Date (Located near the bottom of each graphic)

I. Values on the screen shall be reported dynamically per the change of value standards noted.
   1. Point units shall be shown next to all values using standard units as defined within the specifications above.
   2. Descriptions for points shall be typed into the background and not typed into the graphic.
   3. All analog and binary graphic points trended shall link to the 24-hour controller level trend chart for viewing through direct links from the graphic.
   4. Graphical animations shall be included for the following types of equipment/components of the BAS (where applicable)
      a. Pumps
      b. Fans
      c. Dampers
      d. Interactable Buttons/knobs/gauges
      e. Blinking Objects
      f. Light Fixture Output
   5. All equipment graphics shall include a document link on graphics related to the applicable equipment:
      a. As-Built Sequence of Operation in "pdf" format. Location of this data shall be confirmed with Froedtert Health IT. A URL link to a virtual cloud storage shall be reviewed with Froedtert Health IT until a permanent location of data can be determined.
   6. All analog control points shall be polled and updated on the graphics every 10 seconds (adj.)
   7. All binary control points shall be refreshed on graphics immediately upon change of state.
3.10 SYSTEMS INTEGRATION

A. The following is a description of systems which will be integrated within the Building Automation Systems is coordinated with Froedtert Health

B. Baseline Integration – The following systems and points shall be integrated into the Building Automation System

1. Plumbing
   a. Water heaters
   b. Domestic Water Heat Exchangers
   c. Domestic Water Booster Pumps
   d. Ejector Pumps
   e. Circulation Pumps

2. Fire Protection Systems
   a. Coordinate list of points with Froedtert Health to integrate.

3. HVAC – Equipment with Integrated Controllers
   a. DX Cooling Coils
   b. CRAC units
   c. Heat Pumps

4. Electrical Metering
   a. Integrated Electrical Equipment monitoring.
      1) Generator
      2) ATS
      3) Switchgear
   b. Integrate meters directly with the Building Automation System. When metering software is used connect the software to the BAS using a standard OPC connection.

5. Provide a link to the facility Meter Summary table. The table shall contain at a minimum the following columns from left to right:
   a. Meter tag - clicking on this shall link to the associated system graphic.
   b. Location of meter – Room name and number
   c. Building/Area Served
   d. Units of Measurement (GPM, KW, KVA, etc.)

6. Additional Metering within the building, where applicable, shall be included in this summary, including:
   a. Domestic Water
   b. Heating Hot Water
   c. Chilled Water
   d. Steam
   e. Natural Gas
   f. RO Water Systems

7. Electrical Equipment, including:
   a. Generators
   b. Meters
c. Transfer Switches  
d. ATS  

8. Fire Alarm Monitoring  
a. Integrate points for Supervisory, Trouble, and Alarm signals at a minimum.  

9. Medical Gas Systems  

3.11 FIELD QUALITY CONTROL  
A. All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this specification.  
B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.  
C. Contractor shall have work inspected by local and/or state authorities having jurisdiction over the work.  

3.12 EXISTING EQUIPMENT  
A. Unless otherwise directed, the Contractor is not responsible for the repairs or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the Contractor find existing equipment that requires maintenance, the Engineer is to be notified immediately.  

3.13 WIRING  
A. All control and interlock wiring shall comply with national and local electrical codes and Division 26 of this specification. Where the requirements of this section differ from those in Division 26, the requirements of this section shall take precedence.  
B. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway according to NEC and Division 26 requirements.  
C. All DDC controllers shall have a dedicated 20 amp circuit. Where convenient more than one controller may be fed from the same 20 amp circuit.  
D. DDC controller outputs shall be wired normally closed for all equipment with status inputs. Outputs shall be wired normally open for all equipment without status inputs.  
E. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be subfused when required to meet Class 2 current limit.)  
1. All DDC controller input/output device wiring is to be run in metallic raceway with the following exceptions:  
a. Suspended Ceilings – If such ceiling is a return or supply plenum the cable shall be plenum rated.  
b. Chases  
c. Junction Boxes – Mounted within 3 feet of the device. Flexible metal raceway may be used between device and junction box.  
2. All devices utilizing modular type connectors will utilize factory fabricated cables or a combination of factory fabricated cables and terminal blocks. Field fabrication of modular plug terminated cables is not acceptable.  
3. Any fittings, junction boxes, or raceway installed outside will be rated for outside use.  
4. All threaded connectors are to be fitted with plastic bushings.
5. Any raceway, through, or junction box containing input/output wiring and/or communications cables shall be dedicated for such use, containing no conductors 40 volts or higher.

F. Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

G. Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 3 m (10 ft.) intervals.

H. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, ceiling suspension systems, through metal studs or wide zip-ties.

I. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

J. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

K. All field wiring connections utilizing #10AWG and smaller shall utilize WAGO connectors, clear body style.

L. Maximum allowable voltage for control wiring shall be 24 V. If only high voltages are available, the Contractor shall provide step-down transformers.

M. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

N. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

O. Size of raceway and size and type of wire shall be the responsibility of the Contractor, in keeping with the manufacturer's recommendations and NEC requirement's except as noted elsewhere.

P. Include one pull string in each raceway 2.5 cm (1 in.) or larger.

Q. Use coded conductors throughout with conductors of different colors.

R. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

S. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., steam pipes or flues).

T. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

U. Adhere to this specification's Division 26 requirements where raceway crosses building expansion joints.

V. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.

W. The Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
X. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 1 m (3 ft.) in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.

Y. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

3.14 COMMUNICATION WIRING

A. The Contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.

B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer’s installation recommendations for all communication cabling.

C. Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.

D. Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

E. Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

F. When a cable enters or exits a building, a lightning arrester must be installed between the lines and ground. The lightning arrester shall be installed according to the manufacturer’s instructions.

G. All runs of communication wiring shall be unspliced length when that length is commercially available.

H. All communication wiring shall be labeled to indicate origination and destination data.

I. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.15 FIBER OPTIC CABLE SYSTEM

A. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer’s specifications.

B. All cabling and associated components shall be installed in accordance with manufacturers’ instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.

3.16 INSTALLATION OF SENSORS

A. Install sensors in accordance with manufacturer’s recommendations.

B. Mount sensor rigidly and adequately for the environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

D. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
E. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

F. Low-limit sensors used for coil freeze protection:
   1. Shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 3 m of sensing element for each 1 m² (1 ft of sensing element for each 1 ft²) of coil area.
   2. Where multiple sensors are used:
      a. Wire all sensors in series to protection circuit.
      b. Wire all sensors in series to a binary input point to the BAS to provide alarm.

G. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

H. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

I. Differential Air Static Pressure:
   1. Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
   2. Return Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.
   3. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
   4. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
   5. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.

J. Room Pressure Monitoring Systems: Provide a Room Pressure Monitor for all rooms having a relative pressure requirement, including but not limited to the following rooms:
   1. Operating Rooms (including cystoscopic rooms)
   2. Delivery Rooms
   3. Newborn Intensive Care
   4. Medical Gas Storage
   5. ER Waiting Rooms
   7. Radiology Procedure Rooms
   8. Decontamination areas
   9. Airborne Infection Isolation (AII) Rooms
   10. Protective Environment Rooms
   11. Sterilization Rooms
   12. Clinical Laboratories
   13. Endoscope cleaning
   14. Sterile Storage
   15. Hazardous Material Storage
3.17 FLOW SWITCH INSTALLATION
   A. Use correct paddle for pipe diameter.
   B. Adjust flow switch in accordance with manufacturer’s instructions.

3.18 CONTROL VALVES
   A. For Steam Valves:
      1. For steam pipe sizes NPS 1 inch and smaller: provide a single control valve.
      2. For steam pipe sizes NPS 1-1/4 inch and larger: provide two control valves in 1/3, 2/3 configuration.
   B. For Chilled Water coils
      1. For chilled water connections with nominal capacity of 150 MBH or greater, provide pressure-independent control valves with Water Coil Optimization.

3.19 ACTUATORS
   A. Mount and link control damper actuators according to manufacturer’s instructions.
      1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5 deg. Open position, manually close the damper, and then tighten the linkage.
      2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
      3. Provide all mounting hardware and linkages for actuator installation.
   B. Electric/Electronic:
      1. Dampers: actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5 deg. Available for tightening the damper seals. Actuators shall be mounted following manufacturer’s recommendations.
      2. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer’s recommendations.

3.20 WARNING LABELS
   A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the DDC system.
      1. Labels shall use white lettering (12-point type or larger) on a red background.
      2. Warning labels shall read as follows:
         
         **CAUTION**
         This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to “Off” position before servicing.
   B. Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.
      1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows:

CAUTION

This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

3.21 IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.

B. Permanently label or code each point of field terminal strips to show the instrument or item served.

C. Identify control panels with minimum 1 cm (1/2 in.) letters on laminated plastic nameplates.

D. Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.

E. Identify room sensors relating to terminal box or valves with nameplates.

F. Manufacturers’ nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

G. Identifiers shall match record documents.

H. BAS provider shall include wiring diagrams of controllers located in control panels.
   1. Wiring diagrams shall be printed on 11"x17" paper and plastic laminated. Such diagrams shall affixed to its respective control cabinet by means of a metal chain and “D-ring”. Label sheets with their associated panel number.
   2. Provide USB drive with all documentation of systems served, including but not limited to wiring diagrams, as-built drawings, product literature. Attach USB to inside of cabinet with split-key ring.

3.22 CONTROLLERS

A. Provide a separate controller for each AHU or other HVAC system. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.

B. Building Controllers and Custom Application Controller shall be selected to provide a minimum of 15% spare I/O point capacity for each point type found at each location. If input points are not universal, 15% of each type is required. If outputs are not universal, 15% of each type is required. A minimum of one spare is required for each type of point used.
   1. Future use of spare capacity shall require providing the field device, field wiring, point database definition, and custom software. No additional controller boards or point modules shall be required to implement use of these spare points.

3.23 PROGRAMMING

A. Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25% of available memory free for future use.

B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index. Contractor shall follow naming convention used by Froedtert Hospital Facilities Management Staff.
C. Software Programming:

1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the Contractor. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:

   a. Text-Based:
      1) Must provide actions for all possible situations.
      2) Must be modular and structured.
      3) Must be commented.

   b. Graphic-Based:
      1) Must provide actions for all possible situations.
      2) Must be documented.

   c. Parameter-Based:
      1) Must provide actions for all possible situations.
      2) Must be documented.

2. Occupancy Adjustments: When requested by the Architect within one year of the date of Substantial Completion, provide on-site assistance in reprogramming of the BAS to suit actual occupied conditions. Provide up to three visits to the site of this purpose.

3. Room numbers shall match existing/final room numbering plan upon the completion of the project. The room numbers indicated on the drawings are not necessarily the final room numbers and may be subject to change by the Owner.

D. Operator Interface:

1. Standard graphics – Provide graphics for all mechanical systems and floor plans of the building. This includes each chilled water system, hot water system, chiller, boiler, air handler, and all terminal equipment. Point information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points such as set points.

2. Show terminal equipment information on a "graphic" summary table. Provide dynamic information for each point shown.

3. The Contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.

3.24 CONTROL SYSTEM CHECKOUT AND TESTING

A. Start-up Testing: All testing listed in this article shall be performed by the Contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the Owner's representative is notified of the system demonstration.

1. The Contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls and accessory equipment furnished under this specification.

2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturer’s recommendations.
4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
5. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The Contractor shall check all control valves and automatic dampers to ensure proper actions and closure. The Contractor shall make any necessary adjustments to valve stem and damper blade travel.
6. Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimum start/stop routines.
7. Alarms and Interlocks:
   a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
   b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
   c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

3.25 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE
   A. Demonstration:
      1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
      2. The tests described in this section are to be performed in addition to the tests that the Contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" article in Part 3 of this specification. The Engineer will be present to observe and review these tests. The Engineer shall be notified at least 10 days in advance of the start of the testing procedures.
      3. The demonstration process shall follow that approved in Part 1, "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.
      4. The Contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to provide the proper operation shall be provided by and operated by the Contractor.
      5. As each control input and output is checked, a log shall be completed showing the date, technician’s initials, and any corrective action taken or needed.
      7. Demonstrate compliance with sequences of operation through all modes of operation.
      8. Demonstrate complete operation of operator interface.
B. DDC Control Loop Tuning

1. The Contractor shall tune control algorithm to actual conditions such that all control sequences are stable, yet control gain is maximized. The Contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop’s response to a change in set point, which represents a change of actuator position of at least 35% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Acceptance criteria are indicated below.

2. Control Algorithm Tuning.

a. Two Position and Proportional Control

1) Control loops for space temperature shall not over or under shoot by more than 2F on start-up conditions.
2) Control loops for humidity shall not over or under shoot by more than 10% relative humidity on start-up conditions.
3) Control loops for duct temperature shall not over or under shoot by more than 5F on start-up conditions.

b. P+I and P+I+D Control and Automatic Control Loop Tuning

1) Control loops shall be tuned to achieve both short-term response and long-term stability.
2) Short-Term Response:

a) Controlled variable shall achieve 80% of a step-change in setpoint within the time shown below. The acceptable number of cycles of over- and under-shoot (error) are as shown below.

b) Controlled variable shall achieve 100% of a step-change in setpoint and stabilize within the time shown below. The acceptable number of cycles of over- and under-shoot (error) are as shown below.

c) All control loops shall be tested and tuned to achieve the above requirements when subjected to a step-change up and a step-change down from setpoint.

d) All allowable times and cycles shown reference the step-change in setpoint.

<table>
<thead>
<tr>
<th>Controlled Variable</th>
<th>Change in Setpoint</th>
<th>80% of Step-Change in Setpoint</th>
<th>100% of Step-Change in Setpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Time (min)</td>
<td>Error</td>
</tr>
<tr>
<td>Duct Temperature</td>
<td>5F</td>
<td>3</td>
<td>--</td>
</tr>
<tr>
<td>Space Temperature</td>
<td>2F</td>
<td>2</td>
<td>--</td>
</tr>
<tr>
<td>Hot Water Temperature</td>
<td>10F</td>
<td>3</td>
<td>--</td>
</tr>
<tr>
<td>Condenser Water Temperature</td>
<td>3F</td>
<td>5</td>
<td>--</td>
</tr>
<tr>
<td>Chilled Water Temperature (small and short systems)</td>
<td>2F</td>
<td>3</td>
<td>--</td>
</tr>
<tr>
<td>Chilled Water Temperature (large or long systems)</td>
<td>2F</td>
<td>5</td>
<td>--</td>
</tr>
<tr>
<td>Duct Relative Humidity</td>
<td>5% RH</td>
<td>3</td>
<td>--</td>
</tr>
<tr>
<td>Space Relative Humidity</td>
<td>5% RH</td>
<td>3</td>
<td>--</td>
</tr>
</tbody>
</table>
### Controllable Variable

<table>
<thead>
<tr>
<th>Controlled Variable</th>
<th>Change in Setpoint</th>
<th>80% of Step-Change in Setpoint</th>
<th>100% of Step-Change in Setpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Time (min)</td>
<td>Error</td>
</tr>
<tr>
<td>Duct Static Pressure (variable speed drives)</td>
<td>0.25” w.c.</td>
<td>1</td>
<td>--</td>
</tr>
<tr>
<td>Building Static Pressure</td>
<td>to be determined in the field</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Differential Pressure</td>
<td>5 psig</td>
<td>2</td>
<td>--</td>
</tr>
<tr>
<td>Water Pressure</td>
<td>to be determined in the field</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam Pressure</td>
<td>to be determined in the field</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Flow</td>
<td>to be determined in the field</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Flow</td>
<td>to be determined in the field</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- When control loop responses cannot be met due to limitations of controlled equipment, provide documentation substantiating such limitations.

  **Example:** Discharge air temperature cannot meet cooling setpoint within the above response times even though the cooling coil valve is fully open. Insufficient on-line chiller capacity, pumping, coil capacity, etc.

3) **Long-Term Response:**

a) **Once the controlled variable has attained setpoint, it shall maintain setpoint within the following:**

   - Duct temperature ±0.25F
   - Space temperature ±0.25F
   - Hot water temperature ±0.50F
   - Condenser water temperature ±0.50F
   - Chilled water temperature ±0.10F
   - Duct relative humidity ±1.0% RH
   - Space relative humidity ±1.0% RH
   - Duct static pressure ±0.05” w.c.
   - Building static pressure ±0.02” w.c.
   - Water differential pressure ±0.50 psig
   - Water pressure to be determined in the field
   - Steam pressure to be determined in the field
   - Air flow to be determined in the field
   - Water flow to be determined in the field

c. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the Architect/Engineer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.

3. Additionally, the following items shall be demonstrated:

a. Interface to the building fire alarm system.

4. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The Contractor shall be responsible for any necessary repairs or revisions to the hardware of software to successfully complete all tests.
C. Acceptance:

1. All tests described in this specification shall have been performed to the satisfaction of both the Engineer and Owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the completion requirements if stated in writing by the Engineer. Such tests shall then be performed as part of the warranty.

2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1, "Submittals."

3.26 CLEANING

A. The Contractor shall clean up all debris resulting from his/her activities daily. The Contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, the Contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.27 TRAINING

A. Provide a minimum of four on-site classroom-training sessions, three days each, throughout the contract period for personnel designated by the Owner.

B. Provide two additional training sessions at 6 and 12 months following building’s turnover. Each session shall be three days in length and must be coordinated with the building Owner.

C. Train the designated staff of Owner’s representative and Owner to enable them to do the following:

1. Day-to-Day Operations:
   a. Proficiently operate the system.
   b. Understand control system architecture and configuration.
   c. Understand DDC system components.
   d. Understand system operation, including DDC system control and optimizing routines (algorithms).
   e. Operate the workstation and peripherals.
   f. Log on and off the system.
   g. Access graphics, point reports, and logs.
   h. Adjust and change system set points, time schedules, and holiday schedules.
   i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals.
   j. Understand system drawings and Operation and Maintenance manual.
   k. Understand the job layout and location of control components.
   l. Access data from DDC controllers and ASCs.
   m. Operate portable operator’s terminals.

2. Advanced Operators:
   a. Make and change graphics on the workstation.
b. Create, delete and modify alarms, including annunciation and routing of these.
c. Create, delete and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals.
d. Create, delete and modify reports.
e. Add, remove and modify system’s physical points.
f. Create, modify and delete programming.
g. Add panels when required.
h. Add operator interface stations.
i. Create, delete, and modify system displays, both graphical and others.
j. Perform DDC system field checkout procedures.
k. Perform DDC controller unit operation and maintenance procedures.
l. Perform workstation and peripheral operation and maintenance procedures.
m. Perform DDC system diagnostic procedures.
n. Configure hardware including PC boards, switches, communication, and I/O points.
o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware.
p. Adjust, calibrate, and replace system components:

   a. Maintain software and prepare backups.
   b. Interface with job-specific, third party operator software.
   c. Add new uses and understand password security procedures.

D. These objectives will be divided into three logical groupings. Participants may attend one or more of these, depending on level of knowledge required.

E. Provide course outline and materials in accordance with the “Submittals” article in Part 1 of this specification. The instructor(s) shall provide one copy of training materials per student.

F. The instructor(s) shall be factory–trained instructors experienced in presenting this material.

G. Classroom training shall be done using a network of working controllers representative of the installed hardware.

END OF SECTION 230900
SECTION 230910 - LABORATORY AIRFLOW CONTROL SYSTEM (VENTURI DAMPER)

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish and install a laboratory airflow control system (LACS) to control the airflow into and out of laboratory rooms. The exhaust flow rate of a laboratory fume hood shall be precisely controlled to maintain a constant average face velocity into the fume hood at either a standard/in-use or standby level based on an operator being present in front of the fume hood. The laboratory control system shall vary the amount of make-up/supply air into the room to operate the laboratories at the lowest possible airflow rates necessary to maintain temperature control, achieve minimum ventilation rates, and maintain laboratory pressurization in relation to adjacent spaces (positive or negative).

B. The system shall include room controllers, fume hood controllers, supply air and exhaust air flow control valves, all associated low voltage wiring and all necessary accessories to implement and integrated system as specified herein. System verification and documentation shall be also be included.

C. All laboratory airflow control system (LACS) components shall be supplied by a single manufacturer and be the responsibility of that manufacturer. System shall be fully integrated in the Building Automation System (BAS) specified in Division 23 Section "Instrumentation and Control for HVAC."

1.2 QUALITY ASSURANCE

A. The plans and specifications for the laboratory airflow control system are based on systems and equipment manufactured by Phoenix Controls Corporation. The laboratory airflow system provider shall be an entity that designs, develops, manufactures and sells products and services to control the environment and airflow of critical spaces using a Quality Management System registered to ISO 9001:2000.

B. Refer to Division 23 Section "Instrumentation and Control for HVAC" for Warranty Requirements. Provide extended warranty which shall commence upon the date of shipment and extend for a period of 36 months whereupon any defects in materials or laboratory airflow control system performance shall be repaired by the supplier at no cost to the Owner.

C. Supplier shall have an in-place support facility within 40 miles of the site with technical staff, spare parts in inventory, and all necessary test and diagnostic equipment.

D. Installation as well as the startup, checkout and commissioning of the LACS shall be by full time employees of the control system manufacturer and shall be fully trained by the system manufacturer.

1.3 SUBMITTALS

A. Refer to Division 23 Section "Instrumentation and Control for HVAC" for submittal requirements.

B. The submittal shall include:

1. Manufacturer’s product data including all equipment components such as fume hood monitors, controllers, air control valves, terminal devices, etc.

2. Shop drawings shall include system wiring diagrams with sequences of operation, schedule of air terminal devices, and a system configuration diagram showing all controller types and locations.
PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturers: Subject to compliance with requirements, provide laboratory airflow control system by one of the following:
   1. Phoenix Controls Corporation.

2.2 LABORATORY SUPPLY AND EXHAUST AIR VALVES

A. The airflow control device shall be a Venturi valve.


C. The airflow control valve shall be pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifoded system.

D. The airflow control valve shall maintain accuracy within ±5% of signal over an airflow turndown range of no less than 16 to 1. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.

E. The airflow control supply valves (SV) and exhaust valves (EV) shall be constructed of one of the following three types:
   1. Class A - This airflow control device shall be used for non-corrosive airstreams such as supply and general exhaust and shall be constructed of 16 gauge aluminum. The device’s shaft and shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of aluminum. The pressure independent springs shall be a spring grade stainless steel. All shaft bearing surfaces shall be made of a Teflon, or polyester, or PPS (polyphenylene sulfide) composite.
   2. Class B - This airflow control device shall be used for moderate corrosive airstreams, shall be used for fume hoods and biosafety cabinets and shall have a baked-on corrosion resistant phenolic coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring grade stainless steel. The internal nuts, bolts, and rivets shall be stainless steel. All shaft bearing surfaces shall be made of a Teflon or PPS (polyphenylene sulfide) composite.
   3. Class C - This airflow control device shall be used for highly corrosive airstreams shall be constructed as defined in paragraph E.2 and in addition, shall have no exposed aluminum or stainless steel components. Shaft support brackets, pivot arm, internal mounting link, and pressure independent springs shall have a baked-on corrosion resistant phenolic coating in addition to the materials defined in paragraph E.2. The internal nuts, bolts, and rivets shall be titanium or phenolic coated stainless steel. Only devices clearly defined as “Class C” valve on project drawings will require this construction.
4. Class D - This airflow control device shall be used for extremely corrosive airstreams, such as acid digestion fume hoods and shall have a PVDF (polyvinylidene fluoride fluoropolymer) coating. The device’s shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel with PVDF coating. The pivot arm and internal mounting link shall be made of 316 or 303 stainless steel with PVDF coating. The pressure independent springs shall be a spring-grade stainless steel with PVDF coating. The internal nuts, bolts and rivets shall be stainless steel with PVDF coating. All shaft bearing surfaces shall be made of Teflon or PPS (polyphenylene sulfide) composite. Only devices clearly defined as extremely corrosion resistant "Class D" on project drawing will require this construction.

F. Actuation:
   1. Provide electrically-actuated valves for variable air volume operation. Provide a CE listed fast acting electronic actuator which shall be factory mounted to the valve. Loss of main power shall cause the valve to position itself in an appropriate failsafe state. Options for these failsafe states include: normally open-maximum position, normally closed-minimum position, or last fail position. This position shall be maintained constantly without external influence, regardless of external conditions on the valve (within product specifications).

G. Pressure Switch: Provide pressure sensor/switch across the valve to provide alarm upon loss of adequate pressure to maintain airflow.

H. Certification:
   1. Each airflow control valve shall be factory calibrated to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of no more than ± 1 percent of signal over the entire range of measurement. Electronic airflow control devices shall be further calibrated and their accuracy verified to ± 5 percent of signal at a minimum of eight different airflows across the full operating range of the device.
   2. All airflow control valves shall be individually marked with device specific and factory characterization data. As a minimum, it should include: tag number, serial number, model number, characterization information (for electronic devices), and quality control inspection numbers. All information shall be stored by the manufacturer. Job related information, such as tag number, serial number and model number, shall be stored by the manufacturer for use with as-built documentation.

2.3 VARIABLE VOLUME FUME HOOD CONTROLLER

A. For variable air volume (VAV) systems, a sash sensor shall be provided to measure the height of each vertically-moving fume hood sash. A sash sensor shall also be provided for horizontal overlapping sashes.

B. A presence and motion sensor shall be provided to determine an operator’s presence in front of a hood by detecting the presence and/or motion of an operator, and to command the laboratory airflow control system from an in-use operating face velocity (e.g., 100 fpm) to a standby face velocity (e.g., 60 fpm) and vice versa.
   1. The sensor shall define a detection zone that extends approximately 20 inches (50 cm) from the front of the fume hood. If the sensor does not detect presence and/or motion in its detection zone within five seconds, it shall command the system to the user adjustable standby face velocity. When the sensor detects the presence and/or motion of an operator within the detection zone, it shall command the system to the in-use face velocity within 1.0 second.
2. The sensor shall have a control circuit that adapts to its specific surroundings and automatically adjusts for inanimate objects placed within its detection zone. It shall map the area into memory and, after a period of five minutes, nullify the image of the inanimate object and return to a standby mode. Operators shall enter and leave the zone with the unit automatically adjusting between in-use and standby modes. If the inanimate object is moved or taken out of the zone, the unit shall automatically re-map the area.

3. Zone presence sensor shall operate with no background light using infrared technology or similar technology.

C. The airflow at the fume hood shall vary in a linear manner between two adjustable minimum and maximum flow set points to maintain a constant face velocity throughout this range. A minimum volume flow shall be set to assure flow through the fume hood even with the sash totally closed.

2.4 LABORATORY ROOM CONTROLLER

A. Each laboratory shall have dedicated laboratory airflow control system.

B. The laboratory airflow control system shall employ individual average face velocity controllers that directly measure the area of the fume hood sash opening and proportionally control the hood’s exhaust airflow to maintain a constant face velocity over a minimum range of 20 to 100 percent of sash travel. The corresponding minimum hood exhaust flow turndown ratio shall be 5 to 1.

C. The hood exhaust airflow control valve shall respond to the fume hood sash opening by achieving 90 percent of its commanded value within one second of the sash reaching 90 percent of its final position (with no more than 5 percent overshoot/undershoot) of required airflow. Rate of sash movement shall be between 1.0 to 1.5 feet per second.

D. The hood exhaust airflow control valve shall be automatically switched between in-use and standby levels based on operator presence immediately in front of the hood. A presence and motion sensor shall activate the switching. The airflow control device shall achieve the required in-use commanded value in less than one second from moment of detection with no more than a 5 percent overshoot or undershoot.

E. The laboratory airflow control system shall maintain specific airflow (± 5 percent of signal within one second of a change in duct static pressure) regardless of the magnitude of the pressure change (within 0.6 inch to 3.0 inch wc), airflow change or quantity of airflow control devices on the manifold.

F. The laboratory airflow control system shall use volumetric offset control to maintain room pressurization. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions such as the raising and lowering of any or all fume hood sashes or rapid changes in duct static pressure.

G. The laboratory airflow control system shall maintain specific airflow (± 5 percent of signal) with a minimum 16 to 1 turndown to insure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.

H. Each supply and associated exhaust valve shall be controlled to maintain an actual CFM airflow differential between total room exhaust and supply air that is equal to quantities indicated on the drawings to meet space pressurization requirements. For negatively pressurized rooms, supply airflow shall be controlled to equal the total room exhaust airflow less the required airflow differential. For positively pressurized rooms, total exhaust airflow shall track supply airflow less the required airflow differential.
I. Exhaust and Supply Airflow Control Valves: Provide airflow control valve which shall use closed loop control to linearly regulate airflow based on a 0 to 10 volt control signal. The device shall generate a 0 to 10 volt feedback signal that is linearly proportional to its airflow.

J. Constant Volume Airflow Control Device: The general purpose constant volume airflow control devices shall maintain a constant airflow set point. It shall be factory calibrated and set for the desired airflow. It shall also be capable of field adjustment for future changes in desired airflow and easily adjustable under a load of 3 inch wc (or less) pressure drop across the valve.

K. Should a power failure or operational failure occur within the controller, the valve damper shall automatically be positioned to the fully open or fully closed (failsafe) position as indicated on the Drawings.

L. Laboratory Control Unit: Provide laboratory control unit to control the supply and general exhaust airflow control valves to maintain proper room pressurization polarity (positive or negative). Each individual laboratory shall have a dedicated laboratory control unit.
   1. The control unit shall be electronic. The inputs shall accept linear feedback signals from supply and exhaust airflow control devices. The output signals shall control supply, and exhaust airflow control valves with signals that are linearly proportional to the desired supply or exhaust airflows.
   2. The control unit shall maintain a constant design offset between the sum of the rooms' total exhaust and supply airflows. This offset shall be field adjustable and represents the volume of air that will enter (or exit) the room from the corridor or adjacent spaces.
   3. The control unit shall provide linear signals that are proportional to all airflow sources, sash sensors, and flow alarms. The signals shall be transmitted to the Building Automation System (BAS) through an integrated control unit that interfaces directly into the facility’s BAS system.
   4. The laboratory control unit may be either panel or valve mounted.
   5. Provide 120 Vac power supply the laboratory’s airflow control systems as specified in Division 23 Section "Instrumentation and Control for HVAC".

2.5 FUME HOOD OPERATOR MONITOR

A. A fume hood monitor shall be provided to receive the sash sensor output, and presence and/or motion signal. This same monitor shall generate and exhaust airflow control signal for the appropriate airflow control device in order to provide a constant average face velocity. Audible and separate visual alarms shall be provided for flow alarm and emergency exhaust conditions. The fume hood monitor shall incorporate the following capabilities:
   1. LED Display which shall display the fume hood exhaust air face velocity as feet per minute (FPM).
   2. Alarm Muting option, which silences the audible alarm for an adjustable time period when the mute button is pushed. If another alarm is generated during the mute period, the new alarm will override the mute delay and the alarm will sound again.
   3. Auto Alarm Muting option, which sets the alarm to mute automatically after 20 seconds.
   4. Emergency Exhaust button with LED, which activates an emergency exhaust mode. In this mode, the exhaust air is at its maximum flow. When activated, the alarm will sound and the LED will flash. To activate emergency exhaust mode, push the button. Push the button again to cancel emergency exhaust mode.
   5. Flow Alarm LED, which illuminates to indicate an unsafe airflow condition. The audible alarm will also activate and may be muted.
   6. Broken retracting cable alarm, an audible alarm with a flashing LED that indicates whether a vertical sash sensor cable is detached, thereby ensuring the fume hood users' safety.
7. Diversity alarm option, a LED that can be activated locally or from the BAS system. No audible alarm will be generated at the fume hood monitor.

8. Energy waste alarm option, which generates a local visual and audible alarm to notify when the fume hood sash is open beyond its minimum flow position and the lights in the room are off. When activated, the LED display will show "ENRG" and the audible alarm will sound until the sash is closed. The light levels at which the alarm is both initiated and cancelled shall be configurable.

9. Fume hood hibernation option, which commands the exhaust flow through the fume hood to the minimum allowed by the exhaust valve when the sash is fully closed and no chemicals are present in the hood. The mode shall be initiated by either a pushbutton sequence on the fume hood monitor, external momentary switch input to the fume hood monitor, or a network command. When activated, the LED display will show "OFF," and the exhaust valve will move to its minimum position or shutoff position. Safety shall be built into the hibernation option, whereby opening the fume hood sash will automatically return the fume hood exhaust to an in-use operating volume as determined by the sash sensor. Fume hood hibernation shall be a point that can be integrated to the BAS System.

2.6 SASH SENSOR

A. Provide, sash position sensors for each fume hood to indicate the actual position of each sash. The sash sensor shall be a precision, linear device with repeatable location accuracy within 1/2 inch.

B. Sash sensors material shall be corrosion resistant.

C. Sash sensors shall allow complete and easy removal of the sashes for cleaning and maintenance.

D. Operational life of each sash sensor shall be a minimum of 1,000,000 full cycles.

E. Sash sensor failure shall be indicated as an alarm at the fume hood operator display panel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The BAS contractor shall furnish and install the entire laboratory airflow controls system. Applicable Division 23 Section "Instrumentation and Control for HVAC" shall be followed.

1. Install the sash sensors, interface boxes, presence and motion sensor, and fume hood monitor on the fume hood under initial supervision of the laboratory airflow control system supplier. Reel-type sash sensors and their stainless steel cables shall be hidden from view. Bar-type sash sensors shall be affixed to the individual sash panels. Sash interface boxes with interface cards shall be mounted in an accessible location.

2. Install the laboratory control unit (if panel-mounted) and wall-mounted power supply (as required) in an accessible location in the designated laboratory room.

3. Install all airflow control valves in the ductwork and connect all airflow control valve linkages.

3.2 SYSTEM STARTUP AND TRAINING

A. System start-up shall be provided by a factory-authorized representative of the laboratory airflow control system manufacturer. Start-up shall include calibrating the fume hood monitor and any combination sash sensing equipment as required. Start-up shall also provide electronic verification of airflow (fume hood exhaust, supply, make-up, general exhaust).
B. The Testing, Adjusting and Balancing (TAB) contractor shall for final verification and reporting of all airflows.

C. The laboratory airflow control system supplier shall furnish a minimum of eight hours of Owner training by factory trained and certified personnel. The training will provide an overview of the job specific airflow control components, verification of initial fume hood monitor calibration, general procedures for verifying airflows of air valves, and general troubleshooting procedures.

D. Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall be provided for each training attendee.

3.3 BAS INTERFACE

A. The following laboratory environment information shall be provided to the BAS:
   1. Fume hood exhaust airflow (cfm).
   2. Laboratory room supply airflow (cfm).
   3. Laboratory room general exhaust airflow (if applicable) (cfm).
   4. Fume hood flow alarm.
   5. Laboratory room airflow alarm.
   6. Fume hood sash position.

B. Information shall be transmitted electronically through protocol translators, seamless LAN connection. Information shall be incorporated into the full system graphics to be provided at the BAS operator workstation. If the electronic approach is used, this contractor shall be responsible for all network wiring and any protocol translators required by the building automation and LACS systems.

C. The LACS system shall accept control inputs (as a minimum) from the BAS as follows.
   1. Laboratory room airflow offset setpoint adjustment.
   2. Laboratory room temperature setpoint adjustment.
   3. Occupied state of Laboratory room controls

3.4 SEQUENCE OF CONTROL FOR LABORATORIES WITHOUT FUME HOODS

A. The volumetric offset system determines all supply and exhaust flows into and out of the space. Supply is varied to maintain a fixed air volume differential between the supply and room exhaust in a closed loop tracking arrangement. A space temperature sensor is used to adjust the temperature control proportional/integral/derivative (PID) loop.

B. Room Pressurization: Supply air volume is less than exhaust air volume in laboratories negative to corridor. Provide offset of 100 cfm for a single door and 150 cfm for a double door. Supply is more than exhaust for positive pressure spaces.

C. The supply and room exhaust air volumes from the space shall be controlled (varied) in such a manner as volumetric offset shall perform both volume (mass) and temperature (energy) calculations and adjustments.

D. Space supply air volume shall be controlled by a space temperature sensor, to maintain space comfort conditions, volumetric offset shall maintain the required air volume offset between the supply and exhaust air volumes.
   1. Corridors: Have supply terminal units only. Maintain constant supply volume. Adjust temperature through reheat coil control.
E. Negative Pressure Spaces: The general exhaust valve shall be modulated to maintain either the minimum ventilation setpoint or to satisfy cooling demand, whichever is higher. The supply flow shall be offset to the exhaust flow to maintain a fixed offset CFM between total exhaust and total supply to keep the space negative at all time. If the air quantity necessary to maintain the ventilation setpoint causes a drop in space temperature below the room setpoint, the reheat coil control valve shall be modulated to maintain setpoint.

F. Positive Pressure Spaces: The supply valve shall be modulated to maintain either the minimum ventilation or cooling setpoint, whichever is higher. The general exhaust is modulated to maintain a fixed offset CFM between total supply and total exhaust to maintain the space positive at all times. If the air quantity, necessary to maintain the ventilation setpoint causes the space temperature to fall, then the reheat coil control valve shall be modulated to maintain space temperature setpoint.

G. Neutral Pressure Spaces: The supply valve shall be modulated to maintain either the minimum ventilation or cooling setpoint, whichever is higher. The general exhaust is modulated to maintain the same CFM as the total supply. If the air quantity, necessary to maintain the ventilation setpoint causes the space temperature to fall, then the reheat coil control valve shall be modulated to maintain space temperature setpoint.

H. Spaces shall be maintained at 72 degrees F (adjustable). During winter unoccupied period space temperature shall be maintained between 68 degree F minimum and at 78 degrees F. maximum.

I. Occupied/Unoccupied Control: In general, a minimum ventilation rate in occupied mode (8 ACH adjustable) and unoccupied mode (4 ACH) shall be maintained.
   1. Occupied/unoccupied scheduling shall be through the BAS or by pushbutton override on the room temperature sensor.
   2. Fume hood flow rates shall not be affected by the occupancy modes.

3.5 SEQUENCE OF CONTROL FOR LABORATORIES WITH FUME HOODS

A. General: Control is similar to laboratory HVAC control specified under Paragraph 3.4 except fume hood control shall be integrated in the Volumetric Offset System.

B. Fume Hood Control:
   1. Alarms: A visual and audible alarm signal (for each individual hood) shall be initiated if the fume hood falls below, or rises above, the low or high alarm setpoints respectively. The audible alarm will continue until the alarm silence button is depressed on the fume hood interface module. The visual alarm will continue until the alarm condition ceases.
   2. Emergency Override: When the emergency override button on the fume hood interface module is depressed, the exhaust valve shall go to its preprogrammed position (the full open position, overriding the "max" position), and the visual and audible alarms will be activated. Depressing the button a second time will return the system to normal operation.
   3. The fume hood controller shall continuously calculate the fume hood exhaust CFM required to maintain the average face velocity set point based upon the total open area of the fume hood and the average face velocity (adjustable) set point.
C. Air Flow Tracking:
   1. As the required total exhaust from the space is reduced because of reduced fume hood usage, the supply air volume delivered to the space shall be reduced to a level where the required air volume offset is being maintained. If the space thermostat requires a greater volume of supply air to condition the space than is being supplied to maintain the required supply/exhaust offset, the general exhaust volume shall be increased and the supply volume from the space shall be increased as required to maintain the offset.

D. Occupied-Unoccupied Control: In general, a minimum ventilation rate in occupied mode (12 ACH adjustable) and unoccupied mode (6 ACH) shall be maintained.
   1. Occupied/unoccupied scheduling shall be through the BAS or by pushbutton override on the room temperature sensor.
   2. Fume hood flow rates shall not be affected by the occupancy modes

3.6 TRAINING

A. Provide a minimum of four (4) on-site classroom-training sessions, three 8-hour sessions each, throughout the contract period for personnel designated by the Owner. Schedule sessions to accommodate multiple shifts of campus staff as requested by Owner.

B. Provide two (2) additional training sessions at 6 and 12 months following building’s turnover. Each session shall be three (3) days in length and must be coordinated with the building Owner.

C. Train the designated staff of owner’s representative and owner to enable them to do the following:
   1. Day-to-Day Operators:
      a. Proficiently operate the system.
      b. Understand control system architecture and configuration.
      c. Understand DDC system components.
      d. Understand system operation, including DDC system control and optimizing routines (algorithms).
      e. Operate the workstation and peripherals.
      f. Log on and off the system.
      g. Access graphics, point reports, and logs.
      h. Adjust and change system set points, time schedules, and holiday schedules.
      i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals.
      j. Understand system drawings and Operation and Maintenance manual.
      k. Understand the job layout and location of control components.
      l. Access data from DDC controllers and ASCs.
      m. Operate portable operator's terminals.
   2. Advanced Operators:
      a. Make and change graphics on the workstation.
      b. Create, delete and modify alarms, including annunciation and routing of these.
      c. Create, delete and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals.
      d. Create, delete and modify reports.
      e. Add, remove and modify system’s physical points.
      f. Create, modify and delete programming.
      g. Add panels when required.
      h. Add operator interface stations.
i. Create, delete, and modify system displays, both graphical and others.

j. Perform DDC system field checkout procedures.

k. Perform DDC controller unit operation and maintenance procedures.

l. Perform workstation and peripheral operation and maintenance procedures.

m. Perform DDC system diagnostic procedures.

n. Configure hardware including PC boards, switches, communication, and I/O points.

o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware.

p. Adjust, calibrate, and replace system components.


a. Maintain software and prepare backups.

b. Interface with job-specific, third party operator software.

c. Add new uses and understand password security procedures.

D. These objectives will be divided into three logical groupings. Participants may attend one or more of these, depending on level of knowledge required.


E. Provide course outline and materials in accordance with the "Submittals" article in Part 1 of this specification. The instructor(s) shall provide one copy of training materials per student.

F. The instructor(s) shall be factory-trained instructors experienced in presenting this material.

G. Classroom training shall be done using a network of working controllers representative of the installed hardware.

END OF SECTION 230910
SECTION 230993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems, and equipment.

1.2 DEFINITIONS

A. DDC: Direct digital control.
B. VAV: Variable air volume.

1.3 HEATING HOT WATER SYSTEM

A. General: Heating hot water system consists of one normal and one stand-by steam-to-water convertors and hot water pumping system circulating water to radiation, reheat coils, unit heaters and cabinet heaters throughout the building.

B. Convertor Control:

1. The BAS shall determine the lead convertor on a cumulative runtime basis. The lead heat exchanger shall be the unit with the least amount of cumulative runtime. When the runtime of the lead heat exchanger exceeds the runtime of the stand-by heat exchanger plus a runtime increment (adj.), the BAS shall issue an alarm to the Operator to rotate heat exchangers. The BAS shall rotate the heat exchangers upon acknowledgment by the Operator.
2. The BAS shall open the automatic isolation valves for the lead heat exchanger. Valve position shall be proven with end switches.
3. Once the isolation valves have been proven open to the lead heat exchanger, the isolation valves for the lag heat exchanger shall close.
4. If either isolation valve for the lead heat exchanger does not report open status, the BAS shall fail-over to the lag heat exchanger. An alarm shall be presented at the BAS workstation.
5. Once the valves for the lead heat exchanger are proven open and there is more than 5 psi (adj.) differential pressure in the hydronic heating loop, the two parallel steam control valves shall modulate in sequence to maintain supply water temperature setpoint (180 degrees F, adj.).

C. Heating Hot Water Distribution System:

1. The BAS shall determine the lead, lag and standby pump on a cumulative runtime basis. The lead pump shall be the unit with the least amount of cumulative runtime. The lag pump shall be the unit with the next least amount of cumulative runtime. The standby pump shall be the unit with the most cumulative runtime. When the runtime of the lead pump exceeds the maximum runtime of both the lag and stand-by pumps, plus a runtime increment (adj.) the BAS shall issue an alarm to the Operator to rotate pumps. The BAS shall rotate the pumps upon acknowledgement by the Operator.
2. Lead heating hot water distribution pump shall run continuously. Pump speed shall modulate to maintain differential pressure setpoint.
3. When lead pump, due to increased flow, cannot maintain differential pressure setpoint continuously for a period of five minutes, the lag pump shall start. Both pumps shall run in parallel at the same speed to maintain differential pressure setpoint.
4. When both pumps are operating at 30% (adj.) speed or less continuously for a period of five minutes (adj.), the lag pump shall be de-energized.
5. Upon failure of lead or lag pump, stand-by pump shall automatically operate.
6. Alternate lead/lag/stand-by operation of pumps based on accumulated run time.
7. The BAS shall monitor the run status of each pump. An alarm shall be presented at the BAS when the pump status does not match command.

1.4 CHILLED WATER SYSTEM

A. System Description:
   1. [TO BE EDITED BY CONSULTING ENGINEER OR PLACED ON PLANS]

B. Cooling Plant Sequencing Control:
   1. [TO BE EDITED BY CONSULTING ENGINEER OR PLACED ON PLANS]

C. Chiller Control:
   1. [TO BE EDITED BY CONSULTING ENGINEER OR PLACED ON PLANS]

D. Chilled Water Distribution System Control:
   1. [TO BE EDITED BY CONSULTING ENGINEER OR PLACED ON PLANS]

E. Cooling Tower Control:
   1. [TO BE EDITED BY CONSULTING ENGINEER OR PLACED ON PLANS]

1.5 AIR HANDLING TYPE-1 CONTROL

A. General: These air handling systems are variable air volume systems serving terminal units through the building.

B. Start/Stop Control:
   1. Provide optimal start/stop scheduling.
   2. During occupied mode, the air handling system shall operate continuously.
   3. During unoccupied mode, the air handling system shall operate as described below.
   4. The system shall start during near the end of the unoccupied period in warm-up/cool-down mode. The start time shall vary such that all spaces are at their occupied temperatures at the beginning of the occupied period.

C. Provide individual control of outside air damper, return air damper and exhaust air damper. Control in unison to provide economizer system of damper control.

D. Supply Fan Control
   1. Supply fan variable speed drive(s) will modulate based on static pressure tip located 2/3 down the supply main duct. The initial static setpoint will 1” WC (adj.).
   2. The BAS shall monitor the position of the damper of all VAV terminal units connected to the air handling unit. The static pressure setpoint shall be reset every 10 minutes in 0.05” WC increments. If none of the dampers are commanded to 80% or more open for 10 minutes, reduce the static pressure setpoint. If one or two dampers are commanded to 95% open or more, maintain the static pressure setpoint. If three or more dampers are commanded to 95% open or more, increase the static pressure setpoint. The minimum static pressure setpoint shall be 0.10” WC (adj.).
   3. When multiple supply fans operate, all shall operate at the same speed.
E. Return Fan Control:
   1. Return fan variable speed drive(s) will modulate based on a duct static pressure sensor located in the return/exhaust air plenum. The return fan shall run to maintain 0.50" w.g. (adj.). The final pressure setting shall be verified by the Testing, Adjusting and Balancing (TAB) Contractor.
   2. When multiple return fans operate, all shall operate at the same speed.

F. Return Fan Control:
   1. Return fan variable speed drive(s) will modulate to maintain return air flow setpoint.
   2. Return air flow setpoint to be calculated as the measured supply air flow minus a differential air flow. The differential air flow shall be determined by the TAB contractor, accounting for exhaust air flows and building pressurization requirements.
   3. When multiple fans operate, all shall operate at the same speed.

G. Outside Air Damper Control:
   1. Outside air damper minimum position is to be determined by the TAB contractor based on traverse measurements. TAB contractor shall determine the outside air damper minimum position at ten (10) supply air flow points to obtain required minimum outside air flow. The ten (1) supply air flow points are to be uniformly distributed between required minimum outside air flow and maximum supply air flow.
   2. The required minimum outside air damper position shall be calculated by the BAS by linear interpolation of the TAB Contractor-provided values based on actual supply air flow rate.
   3. A calculated outside air intake percentage (based on return, mixed and outside air temperatures) shall be displayed on the BAS system for monitoring purpose only.
   4. When the outside air enthalpy is greater than or equal to the return air enthalpy the outside air damper shall be positioned to the minimum outside air position.
   5. When the outside air enthalpy is less than the return air enthalpy, the outside air damper shall modulate open in sequence with the return air damper and relief dampers to satisfy the calculated discharge air requirements.

H. Discharge Air Temperature Control:
   1. The discharge air temperature set point shall initially be 55 degrees (adj.). The BAS shall monitor the position of the reheat coil valves of all VAV terminal units connected to the air handling unit.
   2. The discharge air temperature set point shall be reset every 10 minutes in 0.5 degree increments. If all reheat coil valves are commanded to 20% or more open for 10 minutes, increase the discharge air temperature setpoint. If one or two valves are commanded to less than 20%, maintain the discharge air setpoint. If three or more valves are commanded to less than 20% open, decrease the discharge air temperature setpoint.
   3. The discharge air temperature control loop shall modulate, in sequence, the preheat coil, OA/RA/EA dampers, and cooling coil.

I. Warmup mode: When occupied mode starts, if the return air temperature is less than 68 degrees, the discharge air temperature will be reset to 70 degrees until the return air temperature reaches 70 degrees.

J. Heating Coil Control:
   1. The preheat control loop will modulate the normally open 1/3 capacity and 2/3 capacity modulating steam valves in sequence with the bypass dampers to deliver the required discharge air temperature.
2. The outdoor air damper must be driven to its minimum position before this control loop is allowed to function. On an initial call for heating, the 1/3 valve shall modulate open with the dampers in full bypass. On an additional call for heating, the 2/3 valve shall modulate open with the dampers in full bypass. On a further need for heat, with steam control valves fully open, the bypass dampers shall modulate to satisfy the discharge air requirement. On a call for less heat, the face dampers modulate to full bypass followed by closing the 2/3 valve followed by closing the 1/3 valve. During unoccupied times the control loop shall operate to maintain a mixed air temperature of 45 degrees.

K. Humidifier Control:
1. The humidifier control loop will modulate the normally closed steam valve to maintain a return air humidity of 20% (adj.).
2. A 2-way humidity isolation valve is to be opened only when all of the following are true: the outside air temperature is less than 45 degrees, the static pressure in the duct is greater than 0.10" WC and the discharge air humidity is less than setpoint.
3. A humidity sensor shall be installed after the humidifier to limit the discharge air humidity to 80% R.H. (adj.). The BAS shall alarm if discharge humidity exceeds its limits.

L. Cooling Coil Control:
1. The cooling coil control loop will modulate the normally closed chilled water valve to deliver the required discharge air temperature.
2. A dehumidification strategy shall be put in place to control the return air relative humidity levels. If the relative humidity of the return air exceeds 60% R.H.(adj.) the discharge air setpoint will be reset to its initial set point until the return air humidity falls below 55 % R.H. (adj.)
3. When the chilled water valve is open, the preheat coil steam valves are to be fully closed and the preheat coil bypass damper is to be in full bypass.
4. When outside air temperature is less than 38 degrees the valve shall be commanded to 25% open (chilled water pumps will be energized) to allow circulation within the cooling coil to provide freeze protection.

M. Unoccupied Mode:
1. The system shall be in unoccupied mode only if all spaces are in unoccupied mode; otherwise the system shall be in occupied mode.
2. The air handler shall be commanded to run during unoccupied times if any of the areas served have zone temperatures less than 65 degrees or greater than 78 degrees.
3. When the outside air temperature is less than 65 degrees, the unit shall remain on until all zone temperatures are 67 degrees or higher.
4. When the outside air temperature is greater than 70 degrees, the unit shall remain on until all zone temperatures are 76 degrees or lower.
5. When the outside air temperature is between 65 degrees and 70 degrees, the unit shall be off.
6. When the unit operates during unoccupied times, the outside air damper shall be closed and the humidifier shall be off.

N. Alarms and Notifications:
1. All VFD drives shall be monitored and provide a fault condition to the BAS system.
2. All fan banks are to have a separate VFD drive for each fan,
3. Smoke detectors in the supply and return ductwork shall shutdown the air handler via a supervisory signal from the Fire Alarm Control System if in an alarm condition. Smoke detectors are to be overridden if the air handler is commanded to be in a smoke purge mode as commanded by the Fire Alarm Control System.
4. All smoke dampers are to be monitored by the Fire Alarm Control System and shutdown the air handler via a supervisory signal from the Fire Alarm Control System if any close.
5. Low limit thermostat(s) installed before the chilled water coil are to shutdown the air handler if any temperature drops below 38 degrees.
6. A supply high limit static pressure switch located in the main supply ductwork will shutdown the air handler anytime the pressure exceeds +3.5" (adj.).
7. A return low limit static pressure switch located in the main return ductwork will shutdown the air handler anytime the pressure exceeds -2.0" (adj.)
8. All safeties: fire alarm, smoke dampers, low limit (freeze), high static and low static shall alarm through the BAS system. Where multiple low limit thermostats are provided, provide a common alarm to the BAS system for all low limit thermostat(s).
9. Filters shall be monitored and generate an alarm through the BAS system anytime the static pressure exceeds its adjustable setpoint.
10. The 1/3 capacity steam coil control valve shall fail open. The 2/3 capacity steam control valve shall fail closed.

1.6 AIR HANDLING UNIT TYPE-2 CONTROL

A. General: These air handling systems are variable air volume systems serving terminal units through the building.

B. Start/Stop Control:
1. Provide optimal start/stop scheduling.
2. During occupied mode, the air handling system shall operate continuously.
3. During unoccupied mode, the air handling system shall operate as described below.
4. The system shall start during near the end of the unoccupied period in warm-up/cool-down mode. The start time shall vary such that all spaces are at their occupied temperatures at the beginning of the occupied period.

C. Provide individual control of outside air damper, return air damper and exhaust air damper. Control in unison to provide economizer system of damper control.

D. Supply Fan Control
1. Supply fan variable speed drive(s) will modulate based on static pressure tip located 2/3 down the supply main duct. The initial static setpoint will 1" WC (adj.).
2. The BAS shall monitor the position of the damper of all VAV terminal units connected to the air handling unit. The static pressure setpoint shall be reset every 10 minutes in 0.05" WC increments. If none of the dampers are commanded to 80% or more open for 10 minutes, reduce the static pressure setpoint. If one or two dampers are commanded to 95% open or more, maintain the static pressure setpoint. If three or more dampers are commanded to 95% open or more, increase the static pressure setpoint. The minimum static pressure setpoint shall be 0.10" WC (adj.).
3. When multiple supply fans operate, all shall operate at the same speed.

E. Return Fan Control:
1. Return fan variable speed drive(s) will modulate to maintain the required duct static pressure in the return duct.
2. The return duct static pressure sensor is to be located approximately 2/3 of the length of the vertical return air riser.
3. When multiple fans operate, all shall operate at the same speed.
4. The total supply air volume in each main branch shall be periodically calculated (every 5 minutes (adj.) by summation of the primary air being supplied by each VAV box.
5. Smoke dampers at the main shaft are to be used for control. A supervisory signal from the Fire Alarm Control System shall override any other control command.

6. Each control damper and smoke damper in the return air ductwork shall be controlled to maintain its individual return static pressure setpoint. The return static pressure sensor is to be located upstream of control damper, before any takeoffs, free of any turbulence in the return duct.

7. TAB Contractor shall determine the return air static pressure at the sensing location at maximum and minimum supply air flow so that exhaust air flow is maintained at a constant rate. (Note that the proportional balancing of the return air in each room needs to be completed before this traverse is taken).

\[
\text{Return CFM} = \text{Supply CFM} - \text{Exhaust CFM}
\]

8. The static pressure setpoint will vary between the minimum and maximum static pressures measured by the TAB as follows. The measured Supply CFM is to be obtained as described above.

\[
\text{SPsetpoint} = \text{SPmax flow} \times (\text{Supply CFM measured} / \text{Supply CFM maximum})^{2}
\]

F. Outside Air Damper Control:

1. Outside air damper minimum position is to be determined by the TAB contractor based on traverse measurements. TAB contractor shall determine the outside air damper minimum position at ten (10) supply air flow points to obtain required minimum outside air flow. The ten (1) supply air flow points are to be uniformly distributed between required minimum outside air flow and maximum supply air flow.

2. The required minimum outside air damper position shall be calculated by the BAS by linear interpolation of the TAB Contractor-provided values based on actual supply air flow rate.

3. A calculated outside air intake percentage (based on return, mixed and outside air temperatures) shall be displayed on the BAS system for monitoring purpose only.

4. When the outside air enthalpy is greater than or equal to the return air enthalpy the outside air damper shall be positioned to the minimum outside air position.

5. When the outside air enthalpy is less than the return air enthalpy, the outside air damper shall modulate open in sequence with the return air damper and relief dampers to satisfy the calculated discharge air requirements.

G. Discharge Air Temperature Control:

1. The discharge air temperature set point shall initially be 55 degrees (adj.). The BAS shall monitor the position of the reheat coil valves of all VAV terminal units connected to the air handling unit.

2. The discharge air temperature set point shall be reset every 10 minutes in 0.5 degree increments. If all reheat coil valves are commanded to 20% or more open for 10 minutes, increase the discharge air temperature setpoint. If one or two valves are commanded to less than 20%, maintain the discharge air setpoint. If three or more valves are commanded to less than 20% open, decrease the discharge air temperature setpoint.

3. The discharge air temperature control loop shall modulate, in sequence, the preheat coil, OA/RA/EA dampers, and cooling coil.

H. Warmup mode: When occupied mode starts, if the return air temperature is less than 68 degrees, the discharge air temperature will be reset to 70 degrees until the return air temperature reaches 70 degrees.
I. Heating Coil Control:
   1. The preheat control loop will modulate the normally open 1/3 capacity and 2/3 capacity modulating steam valves in sequence with the bypass dampers to deliver the required discharge air temperature.
   2. The outdoor air damper must be driven to its minimum position before this control loop is allowed to function. On an initial call for heating, the 1/3 valve shall modulate open with the dampers in full bypass. On an additional call for heating the 2/3 valve shall modulate open with the dampers in full bypass. On a further need for heat, with steam control valves fully open, the bypass dampers shall modulate to satisfy the discharge air requirement. On a call for less heat, the face dampers modulate to full bypass followed by closing the 2/3 valve followed by closing the 1/3 valve. During unoccupied times the control loop shall operate to maintain a mixed air temperature of 45 degrees.

J. Humidifier Control:
   1. The humidifier control loop will modulate the normally closed steam valve to maintain a return air humidity of 20% (adj.).
   2. A 2-way humidity isolation valve is to be opened only when all of the following are true: the outside air temperature is less than 45 degrees, the static pressure in the duct is greater than 0.10" WC and the discharge air humidity is less than setpoint.
   3. A humidity sensor shall be installed after the humidifier to limit the discharge air humidity to 80% R.H. (adj.). The BAS shall alarm if discharge humidity exceeds its limits.

K. Cooling Coil Control:
   1. The cooling coil control loop will modulate the normally closed chilled water valve to deliver the required discharge air temperature.
   2. A dehumidification strategy shall be put in place to control the return air relative humidity levels. If the relative humidity of the return air exceeds 60% R.H.(adj.) the discharge air setpoint will be reset to its initial set point until the return air humidity falls below 55 % R.H. (adj.)
   3. When the chilled water valve is open, the preheat coil steam valves are to be fully closed and the preheat coil bypass damper is to be in full bypass.
   4. When outside air temperature is less than 38 degrees the valve shall be commanded to 25 % open (chilled water pumps will be energized) to allow circulation within the cooling coil to provide freeze protection.

L. Unoccupied Mode:
   1. The system shall be in unoccupied mode only if all spaces are in unoccupied mode; otherwise the system shall be in occupied mode.
   2. The air handler shall be commanded to run during unoccupied times if any of the areas served have zone temperatures less than 65 degrees or greater than 78 degrees.
   3. When the outside air temperature is less than 65 degrees, the unit shall remain on until all zone temperatures are 67 degrees or higher.
   4. When the outside air temperature is greater than 70 degrees, the unit shall remain on until all zone temperatures are 76 degrees or lower.
   5. When the outside air temperature is between 65 degrees and 70 degrees, the unit shall be off.
   6. When the unit operates during unoccupied times, the outside air damper shall be closed and the humidifier shall be off.

M. Alarms and Notifications:
   1. All VFD drives shall be monitored and provide a fault condition to the BAS system.
2. All fan banks are to have a separate VFD drive for each fan.
3. Smoke detectors in the supply and return ductwork shall shutdown the air handler via a supervisory signal from the Fire Alarm Control System if in an alarm condition. Smoke detectors are to be overridden if the air handler is commanded to be in a smoke purge mode as commanded by the Fire Alarm Control System.
4. All smoke dampers are to be monitored by the Fire Alarm Control System and shutdown the air handler via a supervisory signal from the Fire Alarm Control System if any close.
5. Low limit thermostat(s) installed before the chilled water coil are to shutdown the air handler if any temperature drops below 38 degrees.
6. A supply high limit static pressure switch located in the main supply ductwork will shutdown the air handler anytime the pressure exceeds +3.5” (adj.).
7. A return low limit static pressure switch located in the main return ductwork will shutdown the air handler anytime the pressure exceeds -2.0” (adj.)
8. All safeties: fire alarm, smoke dampers, low limit (freeze), high static and low static shall alarm through the BAS system. Where multiple low limit thermostats are provided, provide a common alarm to the BAS system for all low limit thermostat(s).
9. Filters shall be monitored and generate an alarm through the BAS system anytime the static pressure exceeds its adjustable setpoint.
10. The 1/3 capacity steam coil control valve shall fail open. The 2/3 capacity steam control valve shall fail closed.

1.7 VAV TERMINAL UNIT/REHEAT/RADIATION CONTROL
A. Temperature Control: A space temperature sensor shall modulate the terminal unit supply air damper (between its maximum and minimum airflow positions) in sequence with the reheat coil and radiation control valve to maintain space temperature.
   1. The terminal unit damper shall modulate to its scheduled heating coil CFM airflow position before the perimeter radiation control valve opens. The reheat control valve shall open upon a further call for heat.
   2. During space occupied periods, space shall be maintained at 73 degrees F (68 degrees F for O.R. Cath and I.R. spaces). During space unoccupied periods, space shall be maintained between 68 degrees F and 76 degrees F to keep space occupant ready. When the air handling is normally off, space temperature shall be maintained with 55 degrees F minimum (by cycling the AHU).
B. Occupied/Unoccupied Control: Lighting Room occupancy sensors shall provide BAS system with room occupied signal.
   1. Occupied Period: Primary air supply to the space shall be open.
   2. Unoccupied Period: The primary air supply shall control to unoccupied airflow setpoint. The terminal unit shall modulate heating and cooling as described above to maintain unoccupied heating and cooling setpoints. Provide fifteen (15) minute (adj.) time delay before switching back to unoccupied mode.

1.8 LIFE SAFETY SYSTEM
A. Stair Pressurization System:
   1. General: System consists of one supply fan introducing outside air into the stairwell for pressurization with an over-pressurization relief damper.
   2. Operation: Upon signal from the BAS system all stair pressurization fans shall operate and their outside air dampers shall open. Associated relief air dampers shall modulate to prevent over-pressurization.
B. Vestibule Ventilation System:
1. General: Systems consists of one supply fan and one exhaust fan with associated dampers. System is designed to supply outside air in excess of 60 ACH (air changes per hour) and exhaust in excess of 90 ACH.
2. Operation: Upon signal from BAS system supply fan and exhaust fan shall operate with associated dampers in open position.

C. Smoke Damper Control:
1. Supervisory signal from the Fire Alarm Control System shall close all stand-alone fire/smoke dampers in ductwork upon general building fire alarm.
2. Provide hardwired interlock of life safety system smoke dampers with associated fan starter such that dampers open before fan starts in both "hand" or "auto" position.

D. Smoke Control Systems Operation and Testing:
1. All smoke dampers and combination fire/smoke dampers are controlled by the Fire Alarm Control System.
2. Each damper shall be supplied with end switches (furnished with damper) to indicate either open or closed position.
3. Each fan shall have current sensors to verify status.
4. Smoke control systems shall have highest control priority.
5. Smoke control sequences shall be executed based on input from the fire alarm system and the firefighters smoke control station (FSCS) as specified and indicated on the drawings.
   a. With selector switch in the "Auto" position vestibule ventilation system and stair pressurization systems shall automatically start upon a general building fire alarm.
   b. Recreation center atrium smoke control system shall automatically start upon fire condition in atrium.
   c. Arena bowl smoke control system shall start automatically upon fire conditioning in bowl.
   d. All air handling systems and exhaust fan shall shut-down upon general building fire alarm.
   e. Smoke purge for each air handling system shall be manual initiated at the FSCS.
6. BAS system shall provide graphic depiction of all smoke control systems indicating each damper position and fan status.
7. Provide system test log to document system test and proof of proper operation of each smoke control system. Test log printout format shall be acceptable to the Fire Department as required for quarterly system operation checkout.

1.9 CABINET HEATERS, UNIT HEATERS, AIR CURTAINS

A. Cabinet Heaters:
1. Space sensor shall through BAS system cycle fan motor and open/close hot water control valve to maintain constant space temperature.
2. Supply all cabinet heaters with 3-way control valves.

B. Unit Heater:
1. Space thermostat shall through BAS cycle fan motor and open/close control valve to maintain 55 degree F minimum space temperature.
2. Energize fan when heating is required.
3. Install fan switch adjacent to temperature sensor which shall override fan cycling to operate fan continuously.
1.10 VENTILATION SYSTEMS

A. Electrical Rooms/Mechanical Rooms/Storage Rooms Ventilation:
   1. Upon rise of space temperature above set point, through BAS system supply fan and when present exhaust fan shall start until space temperature drops below set point.
   2. Provide remote on/off control of each ventilation system through BAS system.
   3. Upon start of fans open associated dampers.

B. Variable Flow Exhaust Systems:
   1. General: Provide variable flow exhaust systems for areas served by a variable speed exhaust fan.
   2. Exhaust fan shall operate continuously. Duct mounted pressure sensor shall modulate exhaust fan to maintain 0.75 inch wc negative pressure.
   3. Constant volume exhaust valves in the exhaust ductwork shall close with the constant volume terminal units serving the space when space is unoccupied.
   4. Duct mounted exhaust air flow meter shall signal air handling unit serving these and adjust unit minimum air flow.
   5. Upon start of fan open associated dampers.

1.11 MISCELLANEOUS CONTROL SYSTEMS

1.12 MISCELLANEOUS MONITORING/ALARMING

A. The BAS shall monitor and alarm the following points at a minimum. In addition to alarming locally, critical alarms shall be sent to the operations center PC Workstation or Emergency Desk. Coordinate final device tie-ins with respective equipment contractors.
   1. System temperatures, pressures, relative humidities, and flows.
   2. System status.
   3. Sump levels.
   4. Sump pumps.
   5. Sewage ejectors.
   6. Fuel oil pumping system.
   7. [Generator running.]
   8. [Generator grouped alarm-trouble, run, overload.]
   9. [ATS switch position.]
   10. [Fire alarm system status.]
   11. [UPS status.]
   12. [Electrical digital metering.]
   13. [Surge protective device (SPD)]

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230993
SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:
   1. Hot water heating piping.
   2. Chilled water piping.
   3. Condenser water piping.
   4. Ground source water piping.
   5. Glycol cooling water piping.
   7. Condensate drain piping.
   8. Blowdown drain piping.
  10. Safety valve inlet and outlet piping.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Pressure seal fittings.
   2. Valves: Include flow and pressure drop curves based on manufacturer’s testing for calibrated orifice balancing valves and automatic flow control valves.
   3. Air control devices.
   5. Hydronic specialties.

B. Shop Drawings:
   1. Layout Drawings: Detail, at 1/4” scale, the piping layouts, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. Installer Qualifications:
      a. Welding certificates.

B. Field Quality Control Test Reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air control devices, Hydronic specialties, and special duty valves to include in emergency, operation and maintenance manuals.

1.5 EXTRA MATERIALS

A. Water Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one (1) year from date of Substantial Completion.
1.6 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installers of Pressure Sealed Joints: Installers shall be certified by pressure seal joint manufacturer as having been trained and qualified to join piping with pressure seal pipe couplings and fittings.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code Steel."

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
   2. Chilled Water Piping: 125 psig at 200 deg F (93 deg C).
   5. Glycol Cooling Water Piping: 125 psig at 150 deg F (66 deg C).
  10. Safety Valve Inlet and Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Drawn Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B).
B. Annealed Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).
C. DWV Copper Tubing: ASTM B 306, Type DWV.
D. Copper or Bronze Pressure Seal Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. NIBCO INC.
      b. Viega.
      c. Grinnell.
   2. Housing: Copper.
   3. O Rings and Pipe Stops: EPDM.
   4. Tools: Manufacturer's special tools.
5. Minimum 200 psig (1379 kPa) working pressure rating at 250 deg F (121 deg C).

E. Wrought Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS
A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.
B. Cast Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.
D. Malleable Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.
E. Cast Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.
F. Wrought Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
G. Wrought Cast and Forged Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   2. End Connections: Butt welding.
   3. Facings: Raised face.

2.4 PLASTIC PIPE AND FITTINGS
A. CPVC Plastic Pipe: ASTM F 441/F 441M, with wall thickness as indicated in "Piping Applications" Article.
B. PVC Plastic Pipe: ASTM D 1785, with wall thickness as indicated in "Piping Applications" Article.
C. Polypropylene Pipe (PP-R): ASTM F 2389 or CSA B137.11, with wall thickness as indicated in "Piping Applications" Article.
   1. Polypropylene pipe fittings: Socket fusion type pipe fittings, ASTM F 2389 with wall thickness as indicated in "Piping Applications" Article.
   2. Where a Plenum-rated Piping System is needed, then the pipe shall be wrapped and/or insulated with standard pipe insulation, field installed. The pipe wrap or insulation shall meet the requirements of CAN/ULC-S102.2-03 or ASTM E84. The system shall have a Flame Spread Classification of less than 25 and Smoke Development rating of less than 50.
   3. When the PP-R pipe will be exposed to direct UV light for more than 20 days, it shall be provided with a Factory applied, UV-resistant coating.

HYDRONIC PIPING

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2.5 JOINING MATERIALS

A. Pipe Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8 inch (3.2 mm) maximum thickness unless otherwise indicated.
      a. Full Face Type: For flat face, Class 125, cast iron and cast bronze flanges.
      b. Narrow Face Type: For raised face, Class 250, cast iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead free alloys. Include water flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper phosphorus alloys for joining copper with copper; or BAg 1, silver alloy for joining copper with bronze or steel.

F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for Joining Plastic Piping:
   1. CPVC Piping: ASTM F 493.
      a. CPVC solvent cement shall have a VOC content of 490 g/L or less.
      b. Adhesive primer shall have a VOC content of 550 g/L or less.
      c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
   2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
      a. PVC solvent cement shall have a VOC content of 510 g/L or less.
      b. Adhesive primer shall have a VOC content of 550 g/L or less.
      c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

H. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.6 TRANSITION FITTINGS

A. Plastic to Metal Transition Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. IPEX Inc.
      c. KBI (King Bros. Industries).
2. One piece fitting with one threaded brass or copper insert and one solvent cement joint end of material and wall thickness to match plastic pipe material.

B. Plastic to Metal Transition Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. IPEX Inc.
   c. KBI (King Bros. Industries).
   d. NIBCO INC; Model #T/S 1710.

2. Brass or copper end, solvent cement joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Central Plastics Company.
   c. Matco Norca.
   d. Watts Regulator Co.
   e. Zurn Industries, LLC; AquaSpec Commercial Faucet Products.

2. Description:
   b. Factory fabricated, bolted, companion flange assembly.
   c. Pressure and Temperature Rating: Pressure and temperature rating shall exceed requirements of piping system in which installed.
   d. End Connections: Solder joint copper alloy and threaded ferrous; threaded solder joint copper alloy and threaded ferrous.

C. Dielectric Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.

2. Description:
   a. Nonconducting materials for field assembly of companion flanges.
   b. Pressure and Temperature Rating: Pressure and temperature rating shall exceed requirements of piping system in which installed.
   c. Gasket: Neoprene or phenolic.
   d. Bolt Sleeves: Phenolic or polyethylene.
   e. Washers: Phenolic with steel backing washers.
D. Dielectric Nipples:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Grinnell Mechanical Products.
      b. Victaulic Company.
   2. Description:
      b. Electroplated steel nipple, complying with ASTM F 1545.
      c. Pressure and Temperature Rating: Pressure and temperature rating shall exceed requirements of piping system in which installed.
      d. End Connections: Male threaded or grooved.
      e. Lining: Inert and noncorrosive, propylene.

2.8 BYPASS CHEMICAL FEEDER
   A. Description: Welded steel construction; 125 psig (860 kPa) working pressure; 5 gal. (19 L) capacity; with fill funnel and inlet, outlet, and drain valves.
      1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS
   A. Hot water heating piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
      1. Type L (Type B), drawn temper copper tubing, wrought copper fittings, and soldered or pressure seal joints.
      2. Schedule 40, Grade B, Type 96 steel pipe; cast iron, malleable iron fittings; cast iron flanges and flange fittings; and threaded joints.
   B. Hot water heating piping, aboveground, NPS 2 1/2 (DN 65) and larger, shall be any of the following:
      1. Schedule 40 steel pipe, wrought steel fittings and wrought cast or forged steel flanges and flange fittings, and welded and flanged joints.
      2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
   C. Hot water heating piping installed belowground and within slabs shall be the following:
      1. Type K (Type A), annealed temper copper tubing, wrought copper fittings, and brazed joints. Use the fewest possible joints.
   D. Chilled water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
      1. Type L (Type B), drawn temper copper tubing, wrought copper fittings, and soldered or pressure seal joints.
      2. Schedule 40 steel pipe; cast iron, malleable iron fittings; cast iron flanges and flange fittings; and threaded joints.
3. Polypropylene pipe, SDS 17.6 or heavier with polypropylene fittings and fusion welded joints. All pipe installed in direct exposure to UV lights shall be provided with manufacturer applied UV barrier.

E. Chilled water piping, aboveground, NPS 2 1/2 (DN 65) and larger, shall be any of the following:
   1. Schedule 40 steel pipe, wrought steel fittings and wrought cast or forged steel flanges and flange fittings, and welded and flanged joints.
   2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
   3. Polypropylene pipe, SDS 17.6 or heavier with polypropylene fittings and fusion welded joints. All pipe installed in direct exposure to UV lights shall be provided with manufacturer applied UV barrier.

F. Chilled water piping installed belowground and within slabs shall be the following:
   1. Type K (Type A), annealed temper copper tubing, wrought copper fittings, and brazed joints. Use the fewest possible joints.

G. Condenser water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
   1. Type L (Type B), drawn temper copper tubing, wrought copper fittings, and soldered or pressure seal joints.
   2. Schedule 40 steel pipe; cast iron, malleable iron fittings; cast iron flanges and flange fittings; and threaded joints.
   3. Polypropylene pipe, SDS 17.6 or heavier with polypropylene fittings and fusion welded joints. All pipe installed in direct exposure to UV lights shall be provided with manufacturer applied UV barrier.

H. Condenser water piping, aboveground, NPS 2 1/2 (DN 65) and larger, shall be any of the following:
   1. Schedule 40 steel pipe, wrought steel fittings and wrought cast or forged steel flanges and flange fittings, and welded and flanged joints.
   2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
   3. Polypropylene pipe, SDS 17.6 or heavier with polypropylene fittings and fusion welded joints. All pipe installed in direct exposure to UV lights shall be provided with manufacturer applied UV barrier.

I. Condenser water piping installed belowground and within slabs shall be the following:
   1. Type K (Type A), annealed temper copper tubing, wrought copper fittings, and brazed joints. Use the fewest possible joints.

J. Ground source water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
   1. Type L (Type B), drawn temper copper tubing, wrought copper fittings, and soldered or pressure seal joints.
   2. Schedule 40 steel pipe; cast iron, malleable iron fittings; cast iron flanges and flange fittings; and threaded joints.
   3. Polypropylene pipe, SDS 17.6 or heavier with polypropylene fittings and fusion welded joints. All pipe installed in direct exposure to UV lights shall be provided with manufacturer applied UV barrier.
K. Ground source water piping, aboveground, NPS 2 1/2 (DN 65) and larger, shall be any of the following:
1. Schedule 40 steel pipe, wrought steel fittings and wrought cast or forged steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
3. Polypropylene pipe, SDS 17.6 or heavier with polypropylene fittings and fusion welded joints. All pipe installed in direct exposure to UV lights shall be provided with manufacturer applied UV barrier.

L. Ground source water piping installed belowground and within slabs shall be the following:
1. Type K (Type A), annealed temper copper tubing, wrought copper fittings, and brazed joints. Use the fewest possible joints.

M. Glycol cooling water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
1. Type L (Type B), drawn temper copper tubing, wrought copper fittings, and soldered or pressure seal joints.
2. Schedule 40 steel pipe; cast iron, malleable iron fittings; cast iron flanges and flange fittings; and threaded joints.
3. Polypropylene pipe, SDS 17.6 or heavier with polypropylene fittings and fusion welded joints. All pipe installed in direct exposure to UV lights shall be provided with manufacturer applied UV barrier.

N. Glycol cooling water piping, aboveground, NPS 2 1/2 (DN 65) and larger, shall be any of the following:
1. Schedule 40 steel pipe, wrought steel fittings and wrought cast or forged steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
3. Polypropylene pipe, SDS 17.6 or heavier with polypropylene fittings and fusion welded joints. All pipe installed in direct exposure to UV lights shall be provided with manufacturer applied UV barrier.

O. Glycol cooling water piping installed belowground and within slabs shall be the following:
1. Type K (Type A), annealed temper copper tubing, wrought copper fittings, and brazed joints. Use the fewest possible joints.

P. Makeup water piping installed aboveground shall be the following:
1. Type L (Type B), drawn temper copper tubing, wrought copper fittings, and soldered or joints.

Q. Makeup Water Piping Installed Belowground and within Slabs: Type K (Type A), annealed temper copper tubing, wrought copper fittings, and brazed joints. Use the fewest possible joints.

R. Condensate Drain Piping: Type M (Type C), drawn temper copper tubing, wrought copper fittings, and soldered joints.

S. Blowdown Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
T. Air Vent Piping:
   1. Inlet: Same as service where installed with metal to plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
   2. Outlet: Type K (Type A), annealed temper copper tubing with soldered or flared joints.

U. Safety Valve Inlet and Outlet Piping for Hot Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal to plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS
A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee's in main pipe, with the branch connected to the bottom of the main pipe for down feed branches. For up feed risers, connect the branch to the top of the main pipe. For branch connections more than 3 pipe sizes smaller than main, use weld-o-lets.

P. Install valves according to Division 23 Section "General Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
R. Install flanges in piping, NPS 2 1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Division 23 Section "Vibration Controls for HVAC" for vibration isolation and wind piping restraints.

V. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for identifying piping.

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Escutcheons for HVAC Piping."

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric nipples.

C. Dielectric Fittings for NPS 2 1/2 and Larger: Use dielectric flanges or flange kits.

3.4 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B 813, water flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead free solder alloy complying with ASTM B 32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Utilize raised face flanges wherever possible; and utilize flat flanges only where needed.

H. Plastic Piping Solvent Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe handling practice of cleaners, primers, and solvent cements.
   2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other than schedule number PVC pipe and socket fittings according to ASTM D 2855.
   4. PVC Nonpressure Piping: Join according to ASTM D 2855.

I. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved end fittings and rigid, grooved end pipe couplings.

J. Pressure Sealed Joints: Use manufacturer recommended tool and procedure. Leave insertion marks on pipe after assembly.

K. Fusion Welded Joints:
   1. Install fittings and joints using socket-fusion, electrofusion, or butt-fusion as applicable for the fitting or joint type. All fusion-weld joints shall be made in accordance with the pipe and fitting manufacturer's specifications and product standards.
   2. Fusion-weld tooling, welding machines, and electrofusion devices shall be as specified by the pipe and fittings manufacturer.
   3. Prior to joining, the pipe and fittings shall be prepared in accordance with ASTM F 2389 and the manufacturer's specifications.
   4. Joint preparation, setting and alignment, fusion process, cooling times and working pressure shall be in accordance with the pipe and fitting manufacturer's specifications.

3.5 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Division 23 Section "Meters and Gages for HVAC Piping."

3.6 FLUSHING, CLEANING AND CHEMICAL TREATMENT

A. FLUSHING
   1. The interior of all pipes shall be free from loose mill scale, sand, dirt, slag, weld splatter, rust and other foreign matter when erected. Coordinate with water treatment contractor.
   2. After erection and welding of piping, all those lines requiring hydrostatic testing shall be flushed with clean water by Contractor. Terminal visual inspection shall occur in the presence and to the satisfaction of the Owner.
   3. After erection and welding of piping, all those lines requiring hydrostatic testing shall be blown free of dirt and debris with clean, dry air by the Contractor. Terminal visual inspection shall occur in the presence and to the satisfaction of the Owner.
   4. Upon completion of flushing, all lines shall be drained at all low points.
5. Provide all necessary pumps, high pressure sprayers, temporary piping connections, spool pieces, valves, hoses, chemicals, detergents, sponges, pigs, brush balls, etc. required. Disconnection of items is part of the work under this section.

6. Clean process or potable water at ambient temperature shall be used for all water flushing. Maintain a reasonable velocity to ensure complete removal of all scale, weld splatter and other debris. Drain water to sewer.

7. Clean, dry compressed air at ambient temperature shall be used for all air flushing. Maintain a reasonable velocity to ensure complete removal of all scale, weld splatter and other debris. Discharge air to atmosphere in a safe manner to protect personnel from flushed debris. Where flushed lines pass through outdoor areas, the dew point of the compressed air shall be low enough to prevent condensing moisture in the lines. Owner's representative shall observe initial discharge and intermittently observe during flush.

8. Orifices shall not be installed before the flushing operation. If any orifices have been installed prior to flushing, they must be removed.

9. Prior to operating any permanently installed in-line pumping equipment, precautions shall be taken to ensure that the pump suction piping is sufficiently cleaned to prevent damage to operating system equipment.

10. Pump operation must be observed and controlled to prevent pump "run out" or "dead heading" during the flushing.

11. After flushing every precaution shall be taken to protect the system from recontamination. Primary attention should be made toward keeping "clean" piping sealed off.

12. Pump suction strainer differential pressure gauges will be monitored and pump operation observed to prevent pump cavitations. Where strainer differential pressure gauges are not available, the strainers will be pulled and checked periodically for particulate build-up.

13. Flush through all vents, drains, and applicable instrument lines during the flushing operation to verify that they are unobstructed.

14. Flush each primary path long enough to obtain a representative sample; if not satisfactory, repeat flush for acceptable sample.

15. All exceptions and deficiencies that occurred during the flushing operations shall be noted, and corrected as required.

B. CLEANING

1. Clean piping systems thoroughly. Purge pipe of construction debris and contamination before placing the systems in service. Use whatever temporary connections are required for cleaning, purging and circulating. Cleaning work shall not be performed until the systems are thoroughly flushed, hydrostatically or pneumatically tested and reviewed by the Owner.

2. Install temporary strainers on suction side of pumps and inlets to tanks, solenoid valves, control valves, and other equipment where permanent strainers are not indicated. Keep these strainers in service until the equipment has been tested, then remove either entire strainer or straining element only. Fit strainers with a line size blowoff valve.

3. Except for steam and condensate systems, the systems shall be bleach cleaned by using a solution of 100 pounds of Dearborn Chemical Co. Dearsol 45 powdered alkaline cleaner for each 1,000 gallons of water in the system. An Owner approved equivalent may be substituted. Fill, vent, and circulate the system with the solution and circulate at least 48 hours. After circulating, each system shall be drained completely. All strainer baskets shall be removed, cleaned and remounted. The complete system shall then be rinsed with clean, potable water and drained.
4. **Acceptance:** Prepare a report based on the satisfactory completion of the cleaning of each piping system or portion of the system. The report shall establish the exact limits of the cleaning. When signed and dated by the Owner, the report shall constitute substantial completion except as noted therein. This report shall contain the cleaning method used, duration of cleaning, disinfecting levels, and other information requested by the Owner. This report shall also include a Contractor supplied marked-up set of Piping Drawings, with the sections of pipe which were cleaned to be yellowed-put and initialed by the Contractor and Owner as they are cleaned. The Contractor shall be responsible for maintaining this set of drawings, which shall be given to the Owner at the completion of the job.

C. **Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:**

1. **pH:** 7.0 to 9.0.
2. **"P" Alkalinity:** 100 to 500 ppm.
3. **Boron:** 100 to 200 ppm.
4. **Corrosion Inhibitor:**
   a. Sodium Nitrate: 1000 to 1500 ppm.
   b. Molybdate: 200 to 300 ppm.
   c. Chromate: 200 to 300 ppm.
   d. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
   e. Chromate Plus Molybdate: 50 to 100 ppm each.
5. **Soluble Copper:** Maximum of 0.20 ppm.
6. **Tolyriazole Copper and Yellow Metal Corrosion Inhibitor:** Minimum of 10 ppm.
7. **Total Suspended Solids:** Maximum of 10 ppm.
8. **Ammonia:** Maximum of 20 ppm.
9. **Free Caustic Alkalinity:** Maximum of 20 ppm.
10. **Microbiological Limits:**
    a. **Total Aerobic Plate Count:** Maximum of 1000 organisms/mL.
    b. **Total Anaerobic Plate Count:** Maximum of 100 organisms/mL.
    c. **Nitrate Reducers:** 100 organisms/mL.
    d. **Sulfate Reducers:** Maximum of zero organisms/mL.
    e. **Iron Bacteria:** Maximum of zero organisms/mL.

D. **Install bypass chemical feeders in each hydronic system:**

1. Install in upright position with top of funnel not more than 48 inches (1200 mm) above the floor.
2. Install feeder in minimum NPS 3/4 (DN 20) bypass line, from main with full size, full port, ball valve in the main between bypass connections.
3. Install NPS 3/4 (DN 20) pipe from chemical feeder drain to nearest equipment drain and include a full size, full port, ball valve.

E. **Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

F. **Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

G. **Fill systems that have antifreeze glycol solutions with the following concentrations:**
2. Chilled Water Piping: Minimum of 40 percent propylene glycol.
3. Dual Temperature Heating and Cooling Water Piping: Minimum of 40 percent propylene glycol.

3.7 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:
   1. Leave joints, including welds, uninsulated and exposed for examination during test.
   2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
   3. Flush hydronic piping systems with clean water for a minimum of 8 hours and until water runs clear; then remove and clean or replace strainer screens. After system chemicals have circulated for two weeks and prior to system balancing, flush system a second time, clean strainers a second time.
   4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
   5. Install safety valve, set at a pressure no more than one third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:
   1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
   2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
   3. Isolate expansion tanks and determine that hydronic system is full of water.
   4. Subject piping system to hydrostatic test pressure 1.5 times the system's working pressure but not less than 100 psi. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
   5. After hydrostatic test pressure has been applied for at least 15 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
   6. Prepare written report of testing.

C. Perform the following before operating the system:
   1. Open manual valves fully.
   2. Inspect pumps for proper rotation.
   3. Set makeup pressure reducing valves for required system pressure.
   4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
   5. Set temperature controls so all coils are calling for full flow.
   6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
   7. Verify lubrication of motors and bearings.

END OF SECTION 232113
SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY
A. Section includes special-duty valves and specialties for the following piping systems:
   1. Hot-water heating piping.
   2. Chilled-water piping.
   3. Condenser-water piping.
   4. Ground source water piping.
   5. Glycol cooling-water piping.
   6. Makeup-water piping.
   7. Condensate-drain piping.
  10. Safety-valve-inlet and -outlet piping.

1.2 ACTION SUBMITTALS
A. Product Data: For each type of the following:
   1. Valves: Include flow and pressure drop curves based on manufacturer’s testing for calibrated-orifice balancing valves and automatic flow-control valves.
   2. Air-control devices.
   3. Hydronic specialties.

1.3 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS
A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.5 QUALITY ASSURANCE
A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS
A. Hydronic piping system components and installation shall be capable of withstanding at a minimum the minimum working pressure and temperature of piping system in which installed. See Division 23 Section "Hydronic Piping".

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VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 Section "Instrumentation and Control for HVAC."

C. Bronze, Calibrated-Orifice, Balancing Valves up to and including NPS 1-1/4-inch:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Armstrong Pumps, Inc.
      b. Bell & Gossett.
      c. Flow Design, Inc.
      d. Griswold Controls.
      e. Hays
      f. Nexus
      g. Tour & Andersson
   2. Body: Bronze, ball type with calibrated orifice or venturi.
   4. Seat: PTFE.
   5. End Connections: Threaded or socket.
   7. Handle Style: Lever, with memory stop to retain set position.
   8. Minimum Working Pressure and Temperature: 175 psig at 250 deg F.

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Armstrong Pumps, Inc.
      b. Bell & Gossett Domestic Pump.
      c. Flow Design, Inc.
      d. Griswold Controls.
      e. Tour & Andersson.
   2. Body: Cast-iron or steel body, ball or globe pattern with calibrated orifice or venturi.
   5. Disc: Glass and carbon-filled PTFE.
   6. Seat: PTFE.
   9. Handle Style: Lever, with memory stop to retain set position.
  10. Minimum Working Pressure and Temperature: 175 psig at 250 deg F.

   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Armstrong Pumps, Inc.
      b. Bell & Gossett Domestic Pump.
      c. Conbraco Industries, Inc.
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<td><strong>d.</strong></td>
<td>Spence Engineering Company, Inc.</td>
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<td><strong>e.</strong></td>
<td>Watts Regulator Co.</td>
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<td><strong>2.</strong></td>
<td><strong>Body:</strong> Bronze.</td>
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<td><strong>3.</strong></td>
<td><strong>Disc:</strong> Glass and carbon-filled PTFE.</td>
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<td><strong>4.</strong></td>
<td><strong>Seat:</strong> Brass.</td>
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<td><strong>5.</strong></td>
<td><strong>Stem Seals:</strong> EPDM O-rings.</td>
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<td><strong>6.</strong></td>
<td><strong>Diaphragm:</strong> EPT.</td>
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<td><strong>7.</strong></td>
<td><strong>Low inlet-pressure check valve.</strong></td>
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<td><strong>8.</strong></td>
<td><strong>Inlet Strainer:</strong> 304 stainless steel, removable without system shutdown.</td>
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<td><strong>9.</strong></td>
<td><strong>Valve Seat and Stem:</strong> Noncorrosive.</td>
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<td><strong>10.</strong></td>
<td><strong>Valve Size, Capacity, and Operating Pressure:</strong> Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.</td>
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**F. Diaphragm-Operated Safety Valves:** ASME labeled.

1. **Manufacturers:** Subject to compliance with requirements, provide products by the following:
   a. Armstrong Pumps, Inc.
   b. Bell & Gossett.
   c. Conbraco Industries, Inc.
   d. Spence Engineering Company, Inc.
   e. Watts Regulator Co.

2. **Body:** Bronze.
3. **Disc:** Glass and carbon-filled PTFE.
4. **Seat:** Brass.
5. **Stem Seals:** EPDM O-rings.
6. **Diaphragm:** EPT.
7. **Wetted, Internal Work Parts:** Brass and rubber.
8. **Valve Seat and Stem:** Noncorrosive.
9. **Valve Size, Capacity, and Operating Pressure:** Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

**G. Automatic Flow-Control Valves:**

1. **Manufacturers:** Subject to compliance with requirements, provide products by the following:
   b. Griswold Controls.
   c. Hays Fluid Controls.

2. **Body:** Brass or ferrous metal.
3. **Flow Control Assembly:** Stainless steel, tamper proof, self-cleaning, and removable spring, or sculptured brass or polyphenylsulfone orifice with an elastomeric diaphragm.
4. **Combination Assemblies:** Include bronze or brass-alloy ball valve.
5. **Identification Tag:** Marked with zone identification, valve number, and flow rate.
6. **Size:** Same as pipe in which installed.
7. **Performance:** Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. **Minimum Working Pressure and Temperature:** 175 psig (1207 kPa) at 225 deg F (121 deg C).
2.3 AIR VENTS

A. Manual Air Vents:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Armstrong Pumps, Inc.
      b. Bell & Gossett
      c. Watts
      d. Taco
   2. Body: Bronze.
   3. Internal Parts: Nonferrous.
   4. Operator: Screwdriver or thumbscrew.
   5. Inlet Connection: NPS 1/2 (DN 15).
   7. Minimum Working Pressure and Temperature: 150 psig at 250 deg. F.

B. Automatic Air Vents:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Armstrong Pumps, Inc.
      b. Bell & Gossett
      c. Watts
      d. Taco
   2. Body: Bronze or cast iron.
   3. Internal Parts: Nonferrous.
   5. Inlet Connection: NPS 1/2 (DN 15).
   7. Minimum Working Pressure and Temperature: 150 psig at 250 deg F.

2.4 EXPANSION TANKS:

A. Bladder-Type Expansion Tanks:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Armstrong Pumps, Inc.
      b. Bell & Gossett
      c. Amtrol
      d. Taco
      e. Wessels
   2. Tank: Welded steel, rated for 150-psig minimum working pressure at 250 deg F operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   3. Bladder: Replaceable internal butyl/EPDM or butyl bladder to isolate the air charge from the fluid.
2.5 AIR SEPARATORS

A. Coalescing Air-Dirt Separator:

1. Manufacturers: Subject to compliance with the requirements, provide product by one of the following:
   a. Spirovent.
   b. Bell and Gossett.
   c. Armstrong Pumps Inc.
   d. Wessels

2. Welded black steel, ASME constructed and labeled for minimum 150 psig water working pressure at 250 deg. F operating temperature; screwed connections up to and including 2 inch NPS; flanged connections for 2-1/2 inch NPS and above; threaded blow-down connection; sized as indicated for full system flow capacity.

3. Separator shall be designed for coalescing type air and dirt separation. Entering velocity at the pipe connections shall not exceed 4 feet per second.

4. Separators specifically designed for high velocity systems may have an entering velocity of up to 10 feet per second. All separators shall include an integral turbulence suppressive coalescing and barrier medium, which must completely fill the separators internal area.

5. Separators are to remove free and entrained air during system operation and continue to eliminate dissolved air and dirt through constant circulation and the coalescing/barrier medium.

6. Each separator is to have a separate venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of venting chamber shall be an integral float actuated brass air vent.

7. The separators shall include a valved side tap to flush floating dirt or liquids and for quick bleeding of larger amounts of air during system fill or refill.

8. Separator shall have the vessel extended below the pipe connections for dirt separation. The internal medium shall act as a barrier to force dirt and sediment to fall from the flow path to a collection chamber for flow down through standard connection and valve.

9. The unit shall include removable lower head for internal inspection.

B. Tangential-Type Air Separators:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Armstrong Pumps, Inc.
   b. Bell & Gossett.
   c. Spirotherm
   d. Taco
   e. Thrush

2. Tank: Welded steel; ASME constructed and labeled for 150-psig minimum working pressure at 250 deg F maximum operating temperature.

3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; flanged connections for NPS 2-1/2 (DN 65) and larger.


2.6 HYDRONIC PIPING SPECIALTIES

A. Y- Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: Perforated 304 stainless-steel basket with 37 percent open area.

B. Basket Strainers:
1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: Perforated 304 stainless-steel basket with 50 percent open area.

C. T-Pattern Strainers:
1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: Perforated 304 stainless-steel basket with 57 percent open area.

D. Stainless-Steel Bellow, Flexible Connectors:
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch (20-mm) misalignment.

E. Spherical, Rubber, Flexible Connectors:
2. End Connections: Steel flanges drilled to align with Classes 150 steel flanges.

F. Expansion Fittings: Comply with requirements in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."

PART 3 - EXECUTION

3.1 APPLICATIONS
A. Install shut off duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.
B. Install balancing valves at each branch connection to return main.
C. Install balancing valves in the return pipe of each heating or cooling terminal circuit.
D. Install check valves at each pump discharge and elsewhere as required to control flow direction.
E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.
G. Install strainers upstream of all control valves and pressure reducing valves.
H. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
I. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
J. Install air separator in pump suction. Install blowdown piping with valve; extend full size to nearest floor drain.
K. Install bladder type expansion tanks on the floor or support from structure above. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.
L. Install stainless steel bellow, flexible connectors at connections to all coils.
M. Install flexible connectors at all pumps: [stainless steel bellow] [spherical rubber].
N. Comply with requirements in Division 23 Section "Vibration Controls for HVAC" for vibration isolation and wind restraints.

END OF SECTION 232116
SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes the following:
      2. Separately coupled, horizontal, in-line centrifugal pumps.
      4. Separately coupled, base-mounted, end-suction centrifugal pumps.
      5. Separately coupled, base-mounted, double-suction centrifugal pumps.
      7. Automatic condensate pump units.

1.2 DEFINITIONS
   A. Buna-N: Nitrile rubber.
   B. EPT: Ethylene propylene terpolymer.

1.3 SUBMITTALS
   A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS
   A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
   B. Shop Drawings:
      1. Layout Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
      2. Wiring Diagrams: Power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE
   A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.
   B. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
   C. Design Criteria: Select pumps and impeller to meet specified conditions within a plus or minus 5 percent correction factor. Pump operating speed shall not exceed 1800 RPM unless otherwise indicated.
D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. UL Compliance: Comply with UL 778 for motor-operated water pumps.

F. Nameplate: Provide pump nameplate indicating pump operating flow (GPM) and head (THD).

1.7 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer’s Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer’s written rigging instructions.

1.8 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

   1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

B. Manufacturers:

   1. Armstrong Pumps, Inc.
   2. Aurora Pump; Division of Pentair Pump Group.
   3. Bell & Gossett; Div. of ITT Industries.
   4. Taco, Inc.
   5. Weinman; Div. of Crane Pumps & Systems.

2.2 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically. Rate pump for 175-psig (1204-kPa) minimum working pressure and a continuous water temperature of 225 deg F (107 deg C).
Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and threaded companion-flange or union end connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: Permanently lubricated ball bearings.

C. Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; and rigidly mounted to pump casing. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.3 SEPARATELY COUPLED, HORIZONTAL, IN-LINE CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally. Rate pump for 175-psig (1204-kPa) minimum working pressure and a continuous water temperature of 225 deg F (107 deg C).

B. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and threaded companion-flange or union end connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: Permanently lubricated ball bearings.

C. Shaft Coupling: Interlocking frame with interconnecting springs capable of absorbing vibration.

D. Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; and resiliently mounted to pump casing. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.4 SEPARATELY COUPLED, VERTICAL, IN-LINE CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically. Rate pump for 175-psig (1204-kPa) 250-psig (1720-kPa) minimum working pressure and a continuous water temperature of 225 deg F (107 deg C).

B. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, and threaded companion-flange or union end connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: Permanently lubricated ball bearings.

C. Shaft Coupling: Axially split spacer coupling.
D. Motor: Single speed, with permanently lubricated, grease-lubricated ball bearings, unless otherwise indicated; rigidly mounted to pump casing with lifting eye and supporting lugs in motor enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.5 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS
A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal. Rate pump for 175-psig (1204-kPa) minimum working pressure and a continuous water temperature of 225 deg F (107 deg C).
B. Pump Construction:
1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and threaded companion-flange flanged connections. Provide integral mount on volute to support the casing, and attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket.
5. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings.
C. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor, provide EPDM coupling sleeve for variable-speed applications.
D. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.
E. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.
F. Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; secured to mounting frame, with adjustable alignment. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.6 SEPARATELY COUPLED, BASE-MOUNTED, DOUBLE-SUCTION CENTRIFUGAL PUMPS
A. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal. Rate pump for 175-psig (1204-kPa) minimum working pressure and a continuous water temperature of 225 deg F (107 deg C) 250 deg F (121 deg C).
Pump Construction:

1. Casing: Horizontally split, cast iron, with threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and ASME B16.1, Class 125 flanges. Casing supports shall allow removal and replacement of impeller without disconnecting piping.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket.
5. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings.

Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor. Provide EPDM coupling sleeve for variable-speed applications.

Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

Motor: Single speed, with grease-lubricated ball bearings, unless otherwise indicated; secured to mounting frame, with adjustable alignment. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.7 SEPARATELY COUPLED, VERTICAL-MOUNTED, DOUBLE-SUCTION CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically. Rate pump for 175-psig (1204-kPa) minimum working pressure and a continuous water temperature of [225 deg F (107 deg C)] [250 deg F (121 deg C)].

B. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, drain plug at bottom of volute, mounting support, and ASME B16.1, Class 125 flanges.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and [Buna-N] [EPT] bellows and gasket.
5. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings.

Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration.

Motor: [Single] [Variable] speed, with grease-lubricated ball bearings, unless otherwise indicated; secured to casing. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
2.8 SEPARATELY COUPLED, VERTICAL-MOUNTED, TURBINE CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, single-stage or multistage, centrifugal, impeller-between-bearings, end-suction pump as defined in HI 2.1-2.2 and HI 2.3; designed for installation with pump and motor shafts mounted vertically and projecting into a sump. Rate pump for 175-psig (1204-kPa) minimum working pressure and a continuous water temperature of 200 deg F (93 deg C).

B. Pump Construction:
   1. Pump Bowl: Cast iron, with replaceable bronze wear ring, basket strainer, and suction bell.
   2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
   4. Pump Bearings: Water-lubricated bronze and rubber sleeve bearings contained in cast-iron housing.
   6. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Seal shall be replaceable without removing the motor or disturbing the piping.

C. Shaft Coupling: Keyed with locking collets.

D. Discharge Head: ASME B16.1, Class 125 discharge flange with threaded gage tapping. Top of discharge head shall have a registered fit to accurately locate the driver.

E. Drive Ratchet: Nonreversing ratchet.

F. Hollow Shaft Motor: Single speed, with grease-lubricated ball bearings, unless otherwise indicated; secured to discharge head. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.9 AUTOMATIC CONDENSATE PUMP UNITS

A. Manufacturers:
   1. Aurora Pump; Division of Pentair Pump Group.
   2. Flowserve Corporation; Div. of Ingersoll-Dresser Pumps.
   3. Little Giant Pump Co.; Subsidiary of Tecumseh Products Co.
   4. MEPCO (Marshall Engineered Products Co.).

B. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch- (1800-mm-) minimum, electrical power cord with plug.

2.10 PUMP SPECIALTY FITTINGS

A. Suction Diffuser: Angle pattern, 300-psig (2060-kPa) pressure rating, cast or ductile-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support.

B. Triple-Duty Valve: Angle or straight pattern, 175-psig (1204-kPa) pressure rating, cast or ductile-iron body, pump-discharge fitting; with drain plug and bronze-fitted shutoff, balancing, and check valve features. Brass gage ports with integral check valve, and orifice for flow measurement.
3.1 EXAMINATION

A. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

B. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES

A. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Division 23 Section "Common Work Results for HVAC."
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.3 PUMP INSTALLATION

A. Comply with HI 1.4 and HI 2.4, as applicable.

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Install continuous-thread hanger rods and vibration isolation hangers of sufficient size to support pump weight. Vibration isolation and restraint devices are specified in Division 23 Section "Vibration Controls for HVAC." Fabricate brackets or supports as required. Hanger and support materials are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

E. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and vibration isolation hangers of sufficient size to support pump weight. Vibration isolation and restraint devices are specified in Division 23 Section "Vibration Controls for HVAC." Hanger and support materials are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

F. Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.
   1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches (19 to 38 mm) between pump base and foundation for grouting.
2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

G. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

3.4 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.

B. Comply with pump and coupling manufacturers' written instructions.

C. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation and HI 2.1-2.5, "Vertical Pumps for Nomenclature, Definitions, Application and Operation."

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install triple-duty valve on discharge side of pumps. Install additional shutoff valve.

F. Install suction diffuser and shutoff valve on suction side of pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install single pressure gage with multiple input selector valve. Pipe to pump suction and discharge, at integral pressure-gage tappings, at inlet to suction diffuser or strainer and at discharge of balancing valve.

I. Install check valve and ball valve on each condensate pump unit discharge.

J. Install electrical connections for power, controls, and devices.

K. Ground equipment according to Division 26 Section "Grounding and Bonding."

L. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Perform the following startup checks for each pump before starting:
   a. Verify bearing lubrication.
   b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   c. Verify that pump is rotating in the correct direction.
5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
7. Open discharge valve slowly.

3.7 DEMONSTRATION
   A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 232123
SECTION 232213 - STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 SUMMARY
A. Section includes pipe and fittings for LP and HP steam and condensate piping:

1.2 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Other building services.
   3. Structural members.
B. Qualification Data: For Installer.
C. Welding certificates.
D. Field quality-control reports.

1.3 QUALITY ASSURANCE
A. Installer Qualifications.
B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
C. Pipe Welding: Qualify procedures and operators according to the following:
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS
A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
   1. HP Steam Piping: 150 psig at 350 deg F.
   2. LP Steam Piping: 125 psig at 250 deg. F.
   3. Condensate Piping: 125 psig at 250 deg F.
   4. Makeup-Water Piping: 80 psig at 150 deg F.
   5. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
   6. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
   7. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 STEEL PIPE AND FITTINGS
A. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.
B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in piping applications articles.

C. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in piping applications articles.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in piping applications articles.

E. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in piping applications articles; raised ground face, and bolt holes spot faced.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   2. End Connections: Butt welding.
   3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless otherwise indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

D. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS

A. LP Steam Piping, NPS 2 (DN 50) and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. LP Steam Piping, NPS 2-1/2 and Larger): Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. Condensate Piping, NPS 2 (DN 50) and smaller, shall be the following:
   1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
D. Condensate Piping, NPS 2-1/2 (DN 65) and larger, shall be the following:
   1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.2 HP STEAM PIPING APPLICATIONS
A. HP Steam Piping, NPS 2 (DN 50) and Smaller: Schedule 80, Type S, Grade B, steel pipe; Class 250 cast-iron fittings; and threaded joints.
B. HP Steam Piping, NPS 2-1/2 and Larger: Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
C. Condensate Piping, NPS 2 (DN 50) and smaller, shall be the following:
   1. Schedule 80, Type S, Grade B, steel pipe; Class 250 cast-iron fittings; and threaded joints.
D. Condensate Piping, NPS 2-1/2 (DN 65) and larger, shall be the following:
   1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.3 ANCILLARY PIPING APPLICATIONS
A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
B. Vacuum-Breaker Piping: Outlet, same as service where installed.
C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.4 PIPING INSTALLATION
A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless otherwise indicated.
D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
E. Install piping to permit valve servicing.
F. Install piping free of sags and bends.
G. Install fittings for changes in direction and branch connections.
H. Install piping to allow application of insulation.
I. Select system components with pressure rating equal to or greater than system operating pressure.
J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
K. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) full port-ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and full port ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

U. Comply with requirements in Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

V. Comply with requirements in Division 23 Section "Vibration Controls for HVAC" for vibration isolation and wind restraints.

W. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for identifying piping.

X. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.
   1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 200 feet.
   2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.

Y. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."

Z. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."

AA. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Escutcheons for HVAC Piping."
3.5 STEAM AND CONDENSATE PIPING SPECIALTIES INSTALLATION
   A. Comply with requirements in Division 23 Section "Steam and Condensate Piping Specialties" for installation requirements for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

3.6 PIPE JOINT CONSTRUCTION
   A. Ream ends of pipes and remove burrs. Bevel plain ends of steel pipe.
   B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
   C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
      1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
      2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
   D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
   E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.7 TERMINAL EQUIPMENT CONNECTIONS
   A. Size for supply and return piping connections shall be the same as or larger than equipment connections.
   B. Install traps and control valves in accessible locations close to connected equipment.
   C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, no bypass is required.
   D. Install vacuum breakers downstream from control valve, close to coil inlet connection.
   E. Install a drip leg at coil outlet.

3.8 FIELD QUALITY CONTROL
   A. Prepare steam and condensate piping according to ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," and as follows:
      1. Leave joints, including welds, uninsulated and exposed for examination during test.
      2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
      3. Flush system with clean water. Clean strainers.
      4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
   B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
   C. Manufacturer’s Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
D. Perform the following tests and inspections:
   1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
   2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
   3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

E. Prepare test and inspection reports.

END OF SECTION 232213
SECTION 232216 - STEAM AND CONDENSATE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY
A. Section includes the following piping specialties for LP steam and condensate piping:
   1. Strainers.
   2. Flash tanks.
   4. Pressure-reducing valves.
   5. Steam traps.
   6. Thermostatic air vents and vacuum breakers.
   7. Steam and condensate meters.

1.2 ACTION SUBMITTALS
A. Product Data: For each type of the following:
   1. Pressure-reducing and safety valve.
   2. Steam trap.
   3. Air vent and vacuum breaker.
   4. Flash tank.
   5. Meter.

1.3 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE
A. Pipe Welding: Qualify procedures and operators according to the following:
   1. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS
A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
   1. HP Steam Piping: 150 psig at 350 deg F.
   2. LP Steam Piping: 125 psig at 250 deg F.
   3. Condensate Piping: 125 psig at 250 deg F.
   4. Makeup-Water Piping: 80 psig at 150 deg F.
   5. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
   6. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
   7. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.
2.2 VALVES
A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."
B. Stop-Check Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. A.Y. McDonald Mfg. Co.
      b. Cincinnati Valve Company.
      c. Crane.
      d. Jenkins Valves.
   2. Body and Bonnet: Malleable iron.
   4. Disc: Cylindrical with removable liner and machined seat.
   5. Stem: Brass alloy.
   6. Operator: Outside screw and yoke with cast-iron handwheel.
   8. Pressure Class: 250.

2.3 STRAINERS
A. Y-Pattern Strainers:
   1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for strainers NPS 2 (DN 50) and smaller; flanged ends for strainers NPS 2-1/2 (DN 65) and larger.
   4. Tapped blowoff plug.
   5. Pressure Class: 250-psig working steam pressure.
B. Basket Strainers:
   1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for strainers NPS 2 (DN 50) and smaller; flanged ends for strainers NPS 2-1/2 (DN 65) and larger.
   3. Strainer Screen: Stainless-steel, 20 mesh strainer, and perforated stainless-steel basket with 50 percent free area.
   4. Pressure Class: 250-psig (1725-kPa) working steam pressure.

2.4 FLASH TANKS
A. Shop or factory fabricated of welded steel according to ASME Boiler and Pressure Vessel Code, for 150-psig rating; and bearing ASME label. Fabricate with tappings for low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety valve, and legs.

2.5 SAFETY VALVES
A. Bronze or Brass Safety Valves: ASME labeled.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2.6 PRESSURE-REDUCING VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Fisher Process Control
   3. Hoffman Specialty
   4. Leslie Controls, Inc.
   6. Spirax Sarco, Inc.

B. ASME labeled.

C. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.

D. Description: Pilot-actuated, diaphragm type, with adjustable pressure range and positive shutoff.

E. Body: Cast iron.
2.7 STEAM TRAPS

A. Thermostatic Traps:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Hoffman Specialty.
      c. Spirax Sarco, Inc.
   2. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
   3. Trap Type: Balanced-pressure.
   4. Bellows: Stainless steel or monel.
   5. Head and Seat: Replaceable, hardened stainless steel.
   6. Pressure Class: 125.

B. Thermodynamic Traps:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Hoffman Specialty.
      c. Spirax Sarco, Inc.
   4. Disc and Seat: Stainless steel.
   5. Maximum Operating Pressure: 600 psig (4140 kPa).

C. Float and Thermostatic Traps:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Hoffman Specialty.
      c. Spirax Sarco, Inc.
   2. Body and Bolted Cap: ASTM A 126, cast iron.
   6. Trap Type: Balanced pressure.
   7. Thermostatic Bellows: Stainless steel or monel.
   8. Thermostatic air vent capable of withstanding 45 deg F (25 deg C) of superheat and resisting water hammer without sustaining damage.

D. Inverted Bucket Traps:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Hoffman Specialty.
      c. Spirax Sarco, Inc.
   2. Body and Cap: Cast iron.
   7. Strainer: Integral stainless-steel inlet strainer within the trap body.

2.8 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Hoffman Specialty.
      c. Spirax Sarco, Inc.
   2. Body: Cast iron, bronze, or stainless steel.
   5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
   7. Maximum Temperature Rating: 350 deg F.

B. Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Hoffman Specialty.
      c. Spirax Sarco, Inc.
   2. Body: Cast iron, bronze, or stainless steel.
   5. O-Ring Seal: EPR.
   7. Maximum Temperature Rating: 350 deg F.
2.9 STEAM METERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. EMCO Flow Systems.
   2. ISTEC Corp.
   4. Spirax Sarco, Inc.

B. Meters shall have a microprocessor to display totalizer flow, flow rate, temperature, pressure, time, and date; alarms for high and low flow rate and temperature.
   1. Computer shall have 4- to 20-mA or 2- to 10-V output for temperature, pressure, and contact closure for flow increments.
   2. Independent timers to store four peak flow rates and total flow.
   3. Interface compatible with central workstation described in Division 23 Section "Instrumentation and Control for HVAC."

C. Sensor: The steam flow sensor shall be one of the following:
   1. Venturi, of stainless-steel construction, for insertion in pipeline between flanges. At least 10:1 turndown with plus or minus 1 percent accuracy of flow rate over full-flow range.
   2. Vortex type with stainless-steel wetted parts and flange connections; and with a piezoelectric sensor removable and serviceable without shutting down the process. At least 10:1 turndown with plus or minus 1 percent accuracy of flow rate over full-flow range.

2.10 CONDENSATE METERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Central Station Steam Co.
   2. Lincoln Meter Company.

B. Body: Cast iron, bronze, or brass.

C. Turbine: Copper, brass, or stainless steel.

D. Connections: Threaded for NPS 2 (DN 50) and smaller and flanged for NPS 2-1/2 (DN 65).

E. Totalizer: Meters shall have a microprocessor to display flow, flow rate, time, and date; alarms for high and low flow rate, pressure, and temperature.
   1. Computer shall have 4- to 20-mA or 2- to 10-V output for temperature, pressure, and contact closure for flow increments.
   2. Independent timers to store four peak flow rates and total flow.
   3. Interface compatible with central workstation specified in Division 23 Section "Instrumentation and Control for HVAC."

F. Pressure Rating: Atmospheric.

G. Maximum Temperature Rating: 250 deg F.
PART 3 - EXECUTION

3.1 VALVE APPLICATIONS
A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.
B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.2 PIPING INSTALLATION
A. Install piping to permit valve servicing.
B. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) full port-ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
C. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping."
D. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
E. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.
F. Install shutoff valve immediately upstream of each dielectric fitting.
G. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and full port ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).
H. Flash Tank:
   1. Pitch condensate piping down toward flash tank.
   2. If more than one condensate pipe discharges into flash tank, install a check valve in each line.
   3. Install thermostatic air vent at tank top.
   4. Install safety valve at tank top.
   5. Install full-port ball valve, and swing check valve on condensate outlet.
   6. Install inverted bucket or float and thermostatic trap at low-pressure condensate outlet, sized for three times the calculated heat load.
   7. Flash tanks with relief to atmosphere are not allowed.
I. Comply with requirements in Division 23 Section "Vibration Controls for HVAC" for vibration isolation and wind restraints.

3.3 STEAM-TRAP INSTALLATION
A. Install steam traps in accessible locations as close as possible to connected equipment.
B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.
3.4 PRESSURE-REDUCING VALVE INSTALLATION
   A. Install pressure-reducing valves in accessible location for maintenance and inspection.
   B. Install bypass piping around pressure-reducing valves, with globe valve equal in size to area of pressure-reducing valve seat ring, unless otherwise indicated.
   C. Install gate valves on both sides of pressure-reducing valves.
   D. Install unions or flanges on both sides of pressure-reducing valves having threaded- or flanged-end connections, respectively.
   E. Install pressure gages on low-pressure side of pressure-reducing valves after the bypass connection according to Division 23 Section "Meters and Gages for HVAC Piping."
   F. Install strainers upstream for pressure-reducing valve.
   G. Install safety valve downstream from pressure-reducing valve station.

3.5 STEAM OR CONDENSATE METER INSTALLATION
   A. Install meters with lengths of straight pipe upstream and downstream according to steam meter manufacturer's written instructions.
   B. Provide data acquisition wiring. See Division 23 Section "Instrumentation and Control for HVAC."

3.6 SAFETY VALVE INSTALLATION
   A. Install safety valves according to ASME B31.1, "Power Piping"; and ASME B31.9, "Building Services Piping."
   B. Pipe safety-valve discharge without valves to atmosphere outside the building.
   C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.
   D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2 (DN 65).

3.7 TERMINAL EQUIPMENT CONNECTIONS
   A. Install traps and control valves in accessible locations close to connected equipment.
   B. Install vacuum breakers downstream from control valve, close to coil inlet connection.

END OF SECTION 232216
SECTION 232223 - STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes electric-driven steam condensate pumps.

1.2 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS
A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated. Indicate pump's operating point on curves. Include receiver capacity and material.
B. Shop Drawings:
   1. Layout Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
   2. Wiring Diagrams: Power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE
A. Source Limitations: Obtain steam condensate pumps through one source from a single manufacturer.
B. Product Options: Drawings indicate size, profiles, and dimensional requirements of steam condensate pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
D. ASME Compliance: Fabricate and label steam condensate pumps to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

1.6 DELIVERY, STORAGE, AND HANDLING
A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
B. Store steam condensate pumps in dry location.
C. Retain protective covers for flanges and protective coatings during storage.
D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
E. Comply with pump manufacturer's written rigging instructions.
1.7 COORDINATION
A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 ELECTRIC-DRIVEN STEAM CONDENSATE PUMPS
A. Description: Factory-fabricated, packaged, electric-driven pumps; with receiver, pump(s), controls, and accessories suitable for operation with steam condensate.
B. Configuration: Duplex floor-mounting pumps with receiver and float switches; rated to pump minimum 210 deg F steam condensate.
   1. Manufacturers:
      a. Domestic Pump; Div. of ITT Industries.
      b. Pentair Pump Group.
      d. Spirax Sarco, Inc.
      e. Sterling, Inc.
   2. Receiver: Floor-mounting, close-grained cast iron, welded steel or stainless steel; externally adjustable float switches; with water-level gage, steam condensate thermometer, discharge-pressure gage for each pump, bronze gate valves between receiver and pumps, flanges for pump mounting, and lifting eyebolts.
   3. Inlet Strainer: Cast iron with self-cleaning bronze screen, dirt pocket, and cleanout plug on receiver inlet.
   4. Pumps: Centrifugal, close coupled, vertical design, permanently aligned, and bronze fitted; with replaceable bronze case rings, stainless-steel shafts, and mechanical seals; mounted on receiver flanges; rated to operate down to 2 feet (6 kPa) of NPSH.
   5. Control Panel: NEMA 250, Type 2 or 12 enclosure with hinged door and grounding lug, mounted on pump; factory wired for single external electrical connection; and with the following components within cabinet:
      a. Motor controller for each pump.
      b. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
      c. Manual lead-lag control to override electrical pump alternator to manually select the lead pump.
      d. Momentary contact "TEST" push button on cover for each pump.
      e. Numbered terminal strip.
      f. Disconnect switch.
      g. Fused transformer for control circuit.
6. Capacities and Characteristics: Refer to Drawings.

C. Configuration: Duplex floor-mounting pump with elevated receiver, float switches, and connecting piping; rated to pump 212 deg F (100 deg C) steam condensate.

1. Manufacturers:
   a. Domestic Pump; Div. of ITT Industries.
   b. Skidmore Div.; Vent-Rite Valve Corp.
   d. Spirax Sarco, Inc.

2. Receiver: Close-grained cast iron, welded steel, or stainless steel, mounted on fabricated-steel supports; externally adjustable float switches; with water-level gage, steam condensate thermometer, pump discharge pressure gages, bronze isolation valves between receiver and pumps, and lifting eyebolts.

3. Inlet Strainer: Cast iron with self-cleaning bronze screen, dirt pocket, and cleanout plug on receiver inlet.

4. Pumps: Centrifugal, close coupled, permanently aligned, and bronze fitted; with replaceable bronze case rings, stainless-steel shafts, and mechanical seals; mounted on base below receiver; rated to operate with a minimum of 2 feet (6 kPa) of NPSH.

5. Pipe: ASTM A 53/A 53M, Type S, Grade B or ASTM A 106; Schedule 80; seamless steel.

6. Fittings NPS 2 (DN 50) and Smaller: ASME B16.1, Class 125 cast iron, threaded.

7. Fittings NPS 2-1/2 (DN 65) and Larger: ASTM A 234/A 234M, steel, for welded connections.

8. Control Panel: NEMA 250, Type 2 or 12 enclosure with hinged door and grounding lug; mounted on pump; factory wired for single external electrical connection; and with the following components within cabinet:
   a. Motor controller for each pump.
   b. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
   c. Manual lead-lag control to override electrical alternator to manually select the lead pump.
   d. Momentary contact "TEST" push button on cover for each pump.
   e. Numbered terminal strip.
   f. Disconnect switch.
   g. Fused transformer for control circuit.


D. Configuration: Underground duplex pump with basin and float switches; rated to pump 210 deg F steam condensate.

1. Manufacturers:
   a. Domestic Pump; Div. of ITT Industries.
   b. Skidmore Div.; Vent-Rite Valve Corp.
   d. Spirax Sarco, Inc.

2. Basin: Cast iron, with hub-type inlets.
3. Basin Cover: Cast iron or steel with gasketed openings for access, pumps, pump shafts, control rods, discharge piping, and vent connections.
   a. Anchor Flange: Cast iron, attached to basin, in location and of size required to anchor basin to concrete slab.

   a. Casing: Cast iron with open inlet.
   b. Shaft and Bearings: Stainless-steel shaft with oil-lubricated, bronze, intermediate sleeve bearings; 48-inch (1200-mm) maximum intervals where basin depth is more than 48 inches (1200 mm); and grease-lubricated, ball-type, thrust bearings.
   c. Shaft Couplings: Flexible, capable of absorbing vibration.
   d. Seals: Mechanical; with carbon rotating ring, bearing on a ceramic seat held by a stainless-steel spring, and enclosed by a flexible bellows and gasket.
   e. Motors: Vertically mounted on cast-iron pedestal.
   f. Pump Discharge Piping: Manufacturer's standard steel or bronze pipe, unless otherwise indicated.

5. Control Panel: NEMA 250, Type 2 or 12 enclosure with hinged door and grounding lug; mounted on pump; factory wired for single external electrical connection; and with the following components within cabinet:
   a. Motor controller for each pump.
   b. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
   c. Manual lead-lag control to override electrical alternator to manually select the lead pump.
   d. Momentary contact "TEST" push button on cover for each pump.
   e. Numbered terminal strip.
   f. Disconnect switch.
   g. Fused transformer for control circuit.

6. Capacities and Characteristics: Refer to Drawings.

2.3 MOTORS
   A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.
   B. Examine rough installation of steam condensate piping.
   C. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION
A. Install pumps according to Hydraulic Institute 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."
B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
C. Support pumps and piping separately so piping is not supported by pumps.
D. Install pumps on concrete bases. Anchor pumps to bases using inserts or anchor bolts.
E. Install thermometers and pressure gages.
F. Comply with requirements in Division 23 Section "Vibration Controls for HVAC" for vibration isolation and wind restraints.

3.3 CONNECTIONS
A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to machine to allow service and maintenance.
C. Install check valve, gate valve, and globe valve at pump discharge connections for each electric-driven pump.
D. Pipe drain to nearest floor drain for overflow and drain piping connections.
E. Install full-size vent piping to outdoors, terminating in 180-degree elbow at point above highest steam system connection or as indicated.
F. Ground equipment according to Division 26 Section "Grounding and Bonding."
G. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 STARTUP SERVICE
A. Verify that steam condensate pumps are installed and connected according to the Contract Documents.
B. Complete installation and startup checks according to manufacturer's written instructions.
C. Clean strainers.
D. Set steam condensate pump controls.
E. Set pump controls for automatic start, stop, and alarm operation.
F. Perform the following preventive maintenance operations and checks before starting:
   1. Set float switches to operate at proper levels.
   2. Set throttling valves on pump discharge for specified flow.
   3. Check motors for proper rotation.
   4. Test pump controls and demonstrate compliance with requirements.
   5. Replace damaged or malfunctioning pump controls and equipment.
   6. Verify that pump controls are correct for required application.
G. Start steam condensate pumps according to manufacturer's written startup instructions.
3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain steam condensate pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 232223
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.2 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-134a:

B. Line Test Pressure for Refrigerant R-407C:

C. Line Test Pressure for Refrigerant R-410A:

1.3 SUBMITTALS

A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
1. Thermostatic expansion valves.
2. Solenoid valves.
3. Hot-gas bypass valves.
4. Filter dryers.
5. Strainers.
6. Pressure-regulating valves.

B. Shop Drawings:
1. Layout Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
   a. Shop Drawing Scale: 1/4 inch equals 1 foot (1:50).
   b. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
INFORMATIONAL SUBMITTALS
A. Qualification Data:
   1. Installer Qualifications:
      a. Welding certificates.
B. Field Quality Control Test Reports.

CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

QUALITY ASSURANCE
A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

PRODUCT STORAGE AND HANDLING
A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

COORDINATION
A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

COPPER TUBE AND FITTINGS
A. Copper Tube: ASTM B 280, Type ACR.
B. Wrought-Copper Fittings: ASME B16.22.
C. Wrought-Copper Unions: ASME B16.22.
D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
E. Brazing Filler Metals: AWS A5.8.
F. Flexible Connectors:
   2. End Connections: Socket ends.
   3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
   4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
   5. Maximum Operating Temperature: 250 deg F (121 deg C).
2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; Type, Grade, and wall thickness as selected in Part 3 piping applications articles.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.


E. Flanged Unions:
   1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 (DN 25 to DN 40) and ductile iron for NPS 2 to NPS 3 (DN 50 to DN 80). Apply rust-resistant finish at factory.
   2. Gasket: Fiber asbestos free.
   3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
   4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
   5. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.

F. Flexible Connectors:
   2. End Connections:
      a. NPS 2 (DN 50) and Smaller: With threaded-end connections.
      b. NPS 2-1/2 (DN 65) and Larger: With flanged-end connections.
   3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
   4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
   5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.3 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:
   1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
   3. Operator: Rising stem and hand wheel.
   5. End Connections: Socket, union, or flanged.

B. Packed-Angle Valves:
   1. Body and Bonnet: Forged brass or cast bronze.
   2. Packing: Molded stem, back seating, and replaceable under pressure.
   3. Operator: Rising stem.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.

C. Check Valves:
1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig (3.4 kPa).

D. Service Valves:
1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
4. End Connections: Copper spring.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and [24] [115] [208]-V ac coil.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
4. End Connections: Threaded.

G. Thermostatic Expansion Valves: Comply with ARI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: Internal or External.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 24-V ac coil.

I. Straight-Type Strainers:
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.

J. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.

K. Moisture/Liquid Indicators:
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
5. End Connections: Socket or flare.

L. Replaceable-Core Filter Dryers: Comply with ARI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
7. Maximum Pressure Loss: 2 psig (14 kPa).
8. Rated Flow: As required by application.

M. Permanent Filter Dryers: Comply with ARI 730.
   2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
   4. Designed for reverse flow (for heat-pump applications).
   5. End Connections: Socket.
   8. Rated Flow: As required by application.

N. Mufflers:
   2. End Connections: Socket or flare.

O. Receivers: Comply with ARI 495.
   1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
   2. Comply with UL 207; listed and labeled by an NRTL.
   4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
   5. End Connections: Socket or threaded.

P. Liquid Accumulators: Comply with ARI 495.
   2. End Connections: Socket or threaded.

2.4 REFRIGERANTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Atofina Chemicals, Inc.
   2. DuPont Company; Fluorochemicals Div.
   3. Honeywell, Inc.; Genetron Refrigerants.
   4. INEOS Fluor Americas LLC.

C. ASHRAE 34, R-134a: Tetrafluoroethane.
D. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.
E. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-134A
A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
B. Suction Lines NPS 2 to NPS 4 for Conventional Air-Conditioning Applications: Copper, Type ACR drawn-temper tubing and wrought-copper fittings with brazed joints.
C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:
   1. NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
   2. NPS 2 and Larger: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.
D. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.
E. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-407C
A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
B. Suction Lines NPS 2 to NPS 4 for Conventional Air-Conditioning Applications: Copper, Type ACR drawn-temper tubing and wrought-copper fittings with brazed joints.
C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:
   1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with soldered joints.
   2. NPS 2 and Larger: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.
D. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.
E. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.3 PIPING APPLICATIONS FOR REFRIGERANT R-410A
A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
B. Suction Lines NPS 2 to NPS 3-1/2 for Conventional Air-Conditioning Applications: Copper, Type ACR drawn-temper tubing and wrought-copper fittings with brazed joints.
C. Suction Lines NPS 4 and Larger for Conventional Air-Conditioning Applications: Copper, Type ACR drawn-temper tubing and wrought-copper fittings with soldered joints.
D. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:
   1. NPS 1 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
   2. NPS 1-1/4 and Larger: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

E. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

F. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.4 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

E. Install a full-sized, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
   1. Install valve so diaphragm case is warmer than bulb.
   2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
   3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
   1. Solenoid valves.
   2. Thermostatic expansion valves.
   3. Hot-gas bypass valves.
   4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.
3.5 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operation for HVAC Controls" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:
   1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
   2. Install horizontal suction lines with a uniform slope downward to compressor.
   3. Install traps and double risers to entrain oil in vertical runs.
   4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
   1. Shot blast the interior of piping.
2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Comply with requirements in Division 23 Section "Vibration, Seismic, and Wind Controls for HVAC" for vibration isolation and seismic and wind piping restraints.

T. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."

U. Install sleeves for piping penetrations of walls, ceilings and floors. Comply with requirements for sleeves specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping".

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."

3.6 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
   1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
   2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12/D10.12M.
I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.7 FIELD QUALITY CONTROL
A. Perform tests and inspections and prepare test reports.
B. Tests and Inspections:
   1. Comply with ASME B31.5, Chapter VI.
   2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
   3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
      a. Fill system with nitrogen to the required test pressure.
      b. System shall maintain test pressure at the manifold gage throughout duration of test.
      c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
      d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.8 SYSTEM CHARGING
A. Charge system using the following procedures:
   1. Install core in filter dryers after leak test but before evacuation.
   2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
   3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
   4. Charge system with a new filter-dryer core in charging line.

3.9 ADJUSTING
A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
   1. Open shutoff valves in condenser water circuit.
   2. Verify that compressor oil level is correct.
   3. Open compressor suction and discharge valves.
   4. Open refrigerant valves except bypass valves that are used for other purposes.
   5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300
SECTION 232500 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following HVAC water-treatment systems:
   1. Bypass chemical-feed equipment and controls.
   2. Biocide chemical-feed equipment and controls.
   3. Chemical treatment test equipment.
   4. HVAC water-treatment chemicals.
   5. Makeup water softeners.
   6. RO equipment for HVAC makeup water.
   7. Water filtration units for HVAC makeup water.

1.2 DEFINITIONS

A. EEPROM: Electrically erasable, programmable read-only memory.
B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
C. RO: Reverse osmosis.
D. TDS: Total dissolved solids.
E. UV: Ultraviolet.

1.3 PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including hot-water heating, chilled water and glycol cooling, shall have the following water qualities:
   1. pH: Maintain a value within 9.0 to 10.5.
   2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
   3. Boron: Maintain a value within 100 to 200 ppm.
   4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
   5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
   6. TDS: Maintain a maximum value of 5 ppm.
   9. Microbiological Limits:
      a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
      b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/ml.
      c. Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
      d. Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
      e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.
D. Steam Boiler and Steam Condensate:

1. Steam Condensate:
   a. pH: Maintain a value within 7.8 to 8.4.
   b. Total Alkalinity: Maintain a value within 5 to 50 ppm.
   c. Chemical Oxygen Demand: Maintain a maximum value of 15 ppm.
   d. Soluble Copper: Maintain a maximum value of 0.20 ppm.
   e. TDS: Maintain a maximum value of 10 ppm.
   f. Ammonia: Maintain a maximum value of 20 ppm.
   g. Total Hardness: Maintain a maximum value of 2 ppm.

2. Steam boiler shall have the following water qualities:
   a. "OH" Alkalinity: Maintain a value within 200 to 400 ppm.
   b. TDS: Maintain a value within 600 to 1200 ppm.

E. Open hydronic systems, including condenser and/or fluid-cooler spray water, shall have the following water qualities:

1. pH: Maintain a value within 8.0 to 9.1.
2. "P" Alkalinity: Maintain a maximum value of 100 ppm.
3. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
4. Soluble Copper: Maintain a maximum value of 0.20 ppm.
5. TDS: Maintain a maximum value of 10 ppm.
6. Ammonia: Maintain a maximum value of 20 ppm.
7. Free "OH" Alkalinity: Maintain a maximum value of 0 ppm
8. Microbiological Limits:
   a. Total Aerobic Plate Count: Maintain a maximum value of 10,000 organisms/ml.
   b. Total Anaerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
   c. Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
   d. Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
   e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.
9. Polymer Testable: Maintain a minimum value within 10 to 40.

F. Passivation for Galvanized Steel: For the first 60 days of operation.

1. pH: Maintain a value within 7 to 8.
2. Calcium Carbonate Hardness: Maintain a value within 100 to 300 ppm.
3. Calcium Carbonate Alkalinity: Maintain a value within 100 to 300 ppm.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.5 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following products:

1. Bypass feeders.
2. Water meters.
3. Inhibitor injection timers.
4. pH controllers.
5. TDS controllers.
7. Chemical solution tanks.
8. Injection pumps.
9. Ozone generators.
10. UV-irradiation units.
11. Chemical test equipment.
12. Chemical material safety data sheets.
14. RO units.
15. Multimedia filters.
17. Bag- or cartridge-type filters.
18. Centrifugal separators.

B. Shop Drawings:
1. Layout Drawings: Pretreatment and chemical and UV-irradiation biocide treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.
2. Retain subparagraph below if equipment includes wiring.

C. Field Quality Control Test Reports.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For sensors, injection pumps, water softeners, RO equipment, water filtration units, and controllers to include in emergency, operation, and maintenance manuals.

B. Other Informational Submittals:
1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.

1.7 QUALITY ASSURANCE
A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Coordinate electrical connection requirements with Division 26.
1.8 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for cooling, chilled-water piping heating, hot-water piping heating, steam and condensate piping steam and condensate system for humidifier and cooking appliance applications condenser-water piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Provide products and services offered by company currently under contract with the facility. Subject to compliance with requirements, products by one of the following may be provided:

1. Calgon Corporation.
2. Culligan USA, Industrial Div.

2.2 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch (89-mm) fill opening in the top, and NPS 3/4 (DN 20) bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.


2.3 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
2. Body: Bronze.
5. Registration: Gallons (Liters) or cubic feet (cubic meters).
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.
B. Water Meter:
   1. AWWA C701, turbine-type, totalization meter.
   2. Body: Bronze.
   5. Registration: Gallons (Liters) or cubic feet (cubic meters).
   7. Control: Low-voltage signal capable of transmitting 1000 feet (305 m).

C. Water Meter:
   1. AWWA C701, turbine-type, totalization meter.
   2. Body: Bronze.
   5. Registration: Gallons (Liters) or cubic feet (cubic meters).
   7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.

D. Inhibitor Injection Timers:
   1. Microprocessor-based controller with LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation and Control for HVAC."
   2. Programmable timers with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.
   3. Test switch.
   5. Illuminated legend to indicate feed when pump is activated.
   6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
   7. LCD makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.

E. pH Controller:
   1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation and Control for HVAC."
   2. Digital display and touch pad for input.
   3. Sensor probe adaptable to sample stream manifold.
   4. High, low, and normal pH indication.
   5. High or low pH alarm light, trip points field adjustable; with silence switch.
   7. Internal adjustable hysteresis or deadband.
F. **TDS Controller:**
   1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation and Control for HVAC."
   2. Digital display and touch pad for input.
   3. Sensor probe adaptable to sample stream manifold.
   4. High, low, and normal conductance indication.
   5. High or low conductance alarm light, trip points field adjustable; with silence switch.
   8. Internal adjustable hysteresis or deadband.
   9. **Bleed Valves:**
      a. Cooling Systems: Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.
      b. Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.

G. **Biocide Feeder Timer:**
   1. Microprocessor-based controller with digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation and Control for HVAC."
   2. 24-hour timer with 14-day skip feature to permit activation any hour of day.
   3. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer. Prebleed and bleed lockout timers.
   4. Solid-state alternator to enable use of two different formulations.
   5. 24-hour display of time of day.
   6. 14-day display of day of week.
   7. Battery backup so clock is not disturbed by power outages.

H. **Chemical Solution Tanks:**
   1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
   2. Molded cover with recess for mounting pump.

I. **Chemical Solution Injection Pumps:**
   1. Self-priming, positive-displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
   2. Adjustable flow rate.
   3. Metal and thermoplastic construction.
   5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

J. **Chemical Solution Tubing:** Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.
K. Injection Assembly:
   1. Quill: Minimum NPS 1/2 (DN 15) with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
   2. Ball Valve: Two-piece, stainless steel as described in "Stainless-Steel Pipes and Fittings" Article below; and selected to fit quill.
   3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
   4. Assembly Pressure/Temperature Rating: Minimum 600 psig (4137 kPa) at 200 deg F (93 deg C).

2.4 STAINLESS-STEEL PIPES AND FITTINGS
   A. Stainless-Steel Tubing: Comply with ASTM A 269, Type 316.
   B. Stainless-Steel Fittings: Complying with ASTM A 815/A 815M, Type 316, Grade WP-S.
   C. Two-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and 250-psig (1725-kPa) SWP and 600-psig (4140-kPa) CWP ratings.

2.5 CHEMICAL TREATMENT TEST EQUIPMENT
   A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TDS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers, and oxidizing biocide test for open cooling systems.
   B. Sample Cooler:
      1. Tube: Sample.
         a. Size: NPS 1/4 (DN 8) tubing.
         b. Material: ASTM A 666, Type 316 stainless steel.
         d. Temperature Rating: Minimum 850 deg F (454 deg C).
      2. Shell: Cooling water.
         a. Material: ASTM A 666, Type 304 stainless steel.
   3. Capacities and Characteristics:
      a. Tube: Sample.
         1) Flow Rate: [0.25 gpm (0.016 L/s)] <Insert value>.
         2) Entering Temperature: [400 deg F (204 deg C)] <Insert value>.
         3) Leaving Temperature: [88 deg F (31 deg C)] <Insert value>.
         4) Pressure Loss: [6.5 psig (44.8 kPa)] <Insert value>.
      b. Shell: Cooling water.
         1) Flow Rate: [3 gpm (0.19 L/s)] <Insert value>.
         2) Entering Temperature: [70 deg F (21 deg C)] <Insert value>.
         3) Pressure Loss: [1.0 psig (6.89 kPa)] <Insert value>.
C. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.

1. [Two] <Insert number>-station rack for closed-loop systems.
2. [Four] <Insert number>-station rack for open systems.

2.6 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1 "Performance Requirements" Article.

B. Water Softener Chemicals:

1. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock. Resin exchange capacity minimum 30,000 grains/cu. ft. (69 kg/cu. m) of calcium carbonate of resin when regenerated with 15 lb (6.8 kg) of salt.

2. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are not acceptable.

2.7 HVAC MAKEUP WATER SOFTENER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Capital Water Softener, Inc.
2. Culligan International.
3. CUNO Incorporated.
4. Hellenbrand
5. Marlo Incorporated.

B. Description: Twin mineral tanks and one brine tank, factory mounted on skid.

C. Fabricate supports and attachments to tanks as recommended in writing by manufacturer.

D. Mineral Tanks:

1. Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
3. Pressure Rating: 150 psig (1035 kPa) minimum.
4. Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F (5 to at least 38 deg C) <Insert range>.
5. Freeboard: 50 percent, minimum, for backwash expansion above the normal resin bed level.
6. Support Legs or Skirt: Constructed of structural steel, welded or bonded to tank before testing and labeling.
7. Finish: Hot-dip galvanized on exterior and interior of tank after fabrication.
9. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging PE strainers; arranged for even-flow distribution through resin bed.
E. Controls: Automatic; factory mounted on mineral tanks and factory wired.
   1. Adjustable duration of regeneration steps.
   2. Push-button start and complete manual operation override.
   3. Pointer on pilot-control valve shall indicate cycle of operation.
   5. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:
      a. Slow opening and closing, nonslam operation.
      b. Diaphragm guiding on full perimeter from fully open to fully closed.
      c. Isolated dissimilar metals within valve.
      d. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
      e. Float-operated brine valve to automatically measure the correct amount of brine to the softener and refill with fresh water.
      f. Sampling cocks for soft water.
   6. Flow Control: Automatic control of backwash and flush rates over variations in operating pressures that do not require field adjustments. Equip mineral tanks with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in gallons (liters), and automatically resets after regeneration to preset total in gallons (liters) for next service run. Include alternator to regenerate one mineral tank with the other in service.

F. Brine Tank: Combination measuring and wet-salt storing system.
   1. Tank and Cover Material: Fiberglass a minimum of 3/16 inch (4.8 mm) thick; or molded PE a minimum of 3/8 inch (9.5 mm) thick.
   2. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
   3. Size: Large enough for at least four regenerations at full salting.

G. Factory-Installed Accessories:
   1. Piping, valves, tubing, and drains.
   2. Sampling cocks.
   3. Main-operating-valve position indicators.

H. Water Test Kit: Include water test kit in wall-mounting enclosure for water softener.

2.8 RO EQUIPMENT FOR HVAC MAKEUP WATER
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. CUNO Incorporated.
   4. Plymouth Products, Inc.
B. Description: Factory fabricated and tested with RO membrane elements in housings, high-pressure pumps and motors, controls, valves, and prefilter; mounted on skid.
C. Fabricate supports and attachments to tanks as recommended in writing by manufacturer.
D. Skid Assembly: Welded-steel frame coated with epoxy protective finish.
E. RO Membrane and Housing:
   1. Element: Thin-film composite with U-cup brine seal with minimum 98 percent salt rejection based on 2000-ppm water supplied at 225 psig (1551 kPa) and 77 deg F (25 deg C).
   2. Housing: ASTM A 666, Type 304 stainless steel with PVC end caps held in place with stainless-steel straps.

F. High-Pressure Pumps and Motors:
   1. Pump:
      a. Vertical, multistage centrifugal operating at 3500 rpm with ASTM A 666, Type 304 stainless-steel casing, shaft, impellers, and inlet and discharge casting.
      b. Bearings shall be tungsten carbide and ceramic.
      c. Cast-iron frame and flanged suction and discharge connections.
   2. Motor: NEMA-standard, C-faced TEFC motor supported on the pump-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

G. Controls:
   1. Microprocessor-based controller with LCD display.
   2. Interlock for remote start/stop control.
   3. Membrane flush sequence when pumps shut down.
   4. Run time indicator.
   5. Low-pressure safety cutoff.
   6. Panel-mounted gages as follows:
      a. Product and concentrate.
      b. Inlet, cartridge filter outlet, RO feed, RO concentrate, and RO product pressures.
      c. Product conductivity monitor.

H. Valves:
   1. Stainless-steel pump, concentrate, and recycle throttling valves rated for minimum 300 psig (2068 kPa).
   2. Automatic inlet shutoff valve, diaphragm type; solenoid actuated, normally closed, and constructed of glass-reinforced noryl thermoplastic.
   3. PVC valves with EPDM seats and seals for isolation at inlet, and check and sample valves at product and concentrate. Sample valves at cartridge filter outlet, concentrate, and product outlet.

I. Prefilter:
   1. Housing: Polypropylene with built-in relief or vent valve.
   2. Element: Spun-wound polypropylene.

J. Inlet Water Tempering Valve: Thermostatic water-tempering valve to maintain 77 deg F (25 deg C) inlet water temperature to RO unit.

K. Activated Carbon Filter:
   1. Media Tank: Fiberglass-reinforced polyester rated for minimum 150 psig (1035 kPa) with internal backwash distributor and filtered water collector.
   4. Backwash Control: Seven-day time clock.
L. Atmospheric Storage Tank:
   1. **Tank**: Polyethylene single piece with closed top and flat bottom with manway in top, 0.2-micron filter vent, inlet, discharge, and drain piping connections, and bulkhead fittings for level controls.
   2. **Control**: Level switches start and stop RO unit. Low-level limit shall stop repressurization pumps, and signal an alarm.

M. Repressurization Pumps:
   1. **Pumps**: Two close-coupled, single-stage centrifugal pumps, with mechanical seals. Wetted components ASTM A 666, Type 316 stainless steel.
   2. **Controls**: NEMA-4X pump control panel constructed of fiberglass to control pumps, one operating, one standby, with automatic alternator and fail-over control.
   3. **Motor**: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

N. Water Test Kit: Include water test kit in wall-mounting cabinet for RO unit.

O. Capacities and Characteristics: Refer to Drawings.

2.9 FILTRATION EQUIPMENT

A. Bag-Type Filters:
   1. **Manufacturers**: Subject to compliance with requirements, provide products by one of the following:
      a. Filter Specialists, Inc.
      c. PEP Filters, Inc.
      d. Pentair, Inc.
      e. USFilter.
   2. **Description**: Floor-mounting housing with filter bags for removing particles from water.
      a. **Housing**: Corrosion resistant; designed to separate inlet from outlet and to direct inlet through bag-type water filter; with bag support and base, feet, or skirt.
         1) **Pipe Connections** NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
         2) **Steel Housing Pipe Connections** NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5.
         3) **Plastic Housing Pipe Connections** NPS 2-1/2 (DN 65) and Larger: 150-psig (1035-kPa) plastic flanges.
      b. **Bag**: Replaceable; of shape to fit housing.
   3. **Capacities and Characteristics**: Refer to Drawings.

B. Centrifugal Separators:
   1. **Manufacturers**: Subject to compliance with requirements, provide products by one of the following:
      a. LAKOS; a div. of Claude Laval Corporation.
      b. PEP Filters, Inc.
      c. Puroflux Corporation.
      d. USFilter.
2. Description: Simplex separator housing with baffles and chambers for removing particles from water by centrifugal action and gravity.

3. Housing: With manufacturer's proprietary system of baffles and chambers.
   a. Construction: Fabricate and label steel separator housing to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   b. Inlet: Designed with tangential entry to produce centrifugal flow of feedwater.
   c. Vortex Chamber: Designed for downward vortex flow and gravity separation of particles.
   d. Collection Chamber: Designed to hold separated particles.
   e. Outlet: Near top of unit.
   f. Purge: At bottom of collection chamber.
   g. Pipe Connections NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
   h. Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5. Provide stainless-steel flanges if tank is stainless steel.

4. Motorized Purge Valve: Gate or plug pattern valve.
   a. Motorized Valves: Butterfly-type, flanged-end, ductile-iron body, with EPDM valve seat and stem seal; with ASTM B 148 aluminum bronze disc.

5. Strainer: Stainless-steel basket type mounted on pump suction.

6. Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged or threaded joints and malleable, steel welding, or ductile-iron fittings.

7. Piping: ASTM B 88, Type L (ASTM B 88M, Type B) copper water tube, copper-alloy solder-joint fittings, and brazed, flanged joints.

8. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
   a. Casing: Radially split, cast iron.
   b. Pressure Rating: 150 psig (1035 kPa) minimum.
   c. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
   d. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
   e. Seal: Mechanical.
   f. Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

9. Controls: Automatic control of circulating pump and separator purge; factory wired for single electrical connection.
   a. Panel: NEMA 250, Type 4 enclosure.
   d. TDS Controller Interlock: Open separator purge valve with bleed-off control.

10. Capacities and Characteristics: Refer to Drawings.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.
3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install restraints for equipment and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration and, Wind Controls for HVAC" for restraints.

C. Install water testing equipment on wall near water chemical application equipment.

D. Install interconnecting control wiring for chemical treatment controls and sensors.

E. Mount sensors and injectors in piping circuits.

F. Bypass Feeders: Install in closed hydronic systems, including hot-water heating, chilled water and glycol cooling, and equipped with the following:
   1. Install bypass feeder in a bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
   2. Install water meter in makeup water supply.
   3. Install test-coupon assembly in bypass circuit around circulating pumps.
   4. Install a full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
   5. Install a swing check on inlet after the isolation valve.

G. Install automatic chemical-feed equipment for steam boiler and steam condensate systems and include the following:
   1. Install makeup water softener.
   2. Install water meter in makeup water supply.
   3. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
      a. Pumps shall operate for timed interval when contacts close at water meter in makeup water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.
   4. Install test equipment and furnish test-kit to Owner.
   5. Install RO unit for makeup water.
   6. Install TDS controller with sensor and bleed valves.
      a. Bleed valves shall cycle to maintain maximum TDS concentration.
   7. Install inhibitor injection timer with injection pumps and solution tanks.
      a. Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into main steam supply header.

H. Install automatic chemical-feed equipment for condenser and/or fluid-cooler spray water and include the following:
   1. Install makeup water softener.
   2. Install water meter in makeup water supply.
   3. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
      a. Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.
4. Install test equipment and provide test-kit to Owner. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.

5. Install TDS controller with sensor and bleed valves.
   a. Bleed valves shall cycle to maintain maximum TDS concentration.

6. Install pH sensor and controller with injection pumps and solution tanks.
   a. Injector pumps shall operate to maintain required pH.

7. Install biocide feeder alternating timer with two sets of injection pumps and solution tanks.
   a. Injection pumps shall operate to feed biocide on an alternating basis.

3.3 WATER SOFTENER INSTALLATION

A. Install water softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.

B. Install brine lines and fittings furnished by equipment manufacturer but not factory installed.

C. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

D. Install water-testing sets on wall adjacent to water softeners.

3.4 RO UNIT INSTALLATION

A. Install RO unit and storage tank on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor RO unit and storage tank with pumps to substrate.

B. Install interconnecting piping and controls furnished by equipment manufacturer but not factory installed.

C. Install water testing sets on wall adjacent to RO unit.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Division 23 Section "Common Work Results for HVAC."

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Division 23 Section "General-Duty Valves for HVAC Piping."

E. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.

F. Confirm applicable electrical requirements in Division 26 Sections for connecting electrical equipment.
G. Ground equipment according to Division 26 Section "Grounding and Bonding."

H. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.6 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.
   1. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
   1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
   2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
   3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems’ startup procedures.
   4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
   5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
   7. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
   8. Repair leaks and defects with new materials and retest piping until no leaks exist.

D. Remove and replace malfunctioning units and retest as specified above.

E. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article for each required characteristic. Sample boiler water at four-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section.

F. At four-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article.

G. Comply with ASTM D 3370 and with the following standards:

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment. Refer to Division 01 Section "Demonstration and Training."

B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

END OF SECTION 232500
SECTION 2325 – GLYCOL SOLUTIONS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following HVAC water-treatment systems:
   1. Hot Glycol.
   4. Pre-packaged, pressurized glycol make-up system

1.2 DEFINITIONS
A. DI: De-ionized.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following products:
   1. Glycol Solution.
   2. De-ionized Water.
   3. Flushing/Cleaning Solution.
   4. Pre-packaged, pressurized glycol make-up system

1.5 INFORMATIONAL SUBMITTALS
A. Field Quality Control Test Reports.

1.6 QUALITY ASSURANCE
A. No chemical additions shall be made to the glycol water solution until an analysis has been completed by the coolant manufacturer. Should such a chemical addition be required, it will be done in accordance with the recommendations on the analytical as supplied by the manufacturer.

1.7 MAINTENANCE SERVICE
A. The coolant manufacturer shall analyze the fluid bi-annually to ensure the glycol water solution continues to provide corrosion protection within industry standards and at no cost to the Owner.
PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Approved coolant manufacturers are:
   1. Interstate Chemical Co.; NFP/P-300 - [40] [other] percent propylene glycol.
   2. DOW Chemical Co.; Dowfrost HD - [40] [other] percent propylene glycol.

2.2 GLYCOL SOLUTIONS
A. The closed loop piping system shall contain a pre-blended solution of industrially inhibited propylene glycol and de-ionized water. The solution concentration shall provide freeze protection to -10 degrees Fahrenheit.
B. Automotive grade antifreeze is not acceptable.
C. The water used for the dilution of the glycol must meet the following water quality criteria:
   1. Less than 25ppm Sulfate,
   2. Less than 25ppm Chloride,
   3. Less than 1ppm Calcium,
   4. Less than 1ppm Magnesium,
   5. Less than <25ppm Silica.
   6. Electrical conductivity umho/cm @ 25 C. 1.0 max.
   7. Total water hardness must be less than 60ppm and meet the Type II Reagent Water specification as per ASTM D-1193.
D. The selected coolant must meet or exceed the ASTM D-1348 corrosion test for coolants in glassware @ 190 deg. F. for 336 hours. A Certificate of Assurance must be provided by the supplier prior to delivery.
E. The solution shall contain a fluorescent dye to facilitate easy leak detection.

2.3 GLYCOL MAKE-UP UNIT
A. Prefabricated, automatic and autonomous duplex make-up package
B. The package shall be mounted on a sturdy, welded steel frame.
C. Pumps: Provide the unit with duplex pumps
D. Electrical: Single-point connection
E. Storage Tank: Graduated, polyethylene solution container with removable lid designed to work together to maintain specific fill pressures in each independent glycol system.
F. Alarms: Provide the following alarms/controls with the unit:
   1. Low water cut-off alarm, HOA controls,
   2. Magnetic starters with automatic alternation,
   3. Pressure controls for storage tank,
   4. A 110V signal shall be available for a remote alarm.
PART 3 - EXECUTION

3.1 INSTALLATION

A. The mechanical contractor shall meter the initial water fill for the purpose of hydrostatic pressure testing and/or system flushing. After completion of this requirement, the water shall be metered out. This will provide the contractor with a precise measure of coolant required to fill the system as well as the amount of water trapped in the system. This process will allow for any adjustments required prior to delivery of the premixed glycol solution and ensure that the solution strength is in compliance with the specification.

B. Should the concentration still require adjustment after the system has been filled and as a result of trapped water, then drain the required amount of fluid from the system and replace it with the same manufacturer's coolant in its concentrated form. Repeat this process until compliance with this specification is achieved.

3.2 SYSTEM PREPARATION

A. Clean and flush piping system, remove, clean and replace strainer screens once the system water is clear.

B. Water flush applies to the following systems:
   1. Preheat water.
   2. Glycol water.
   3. Heating/Cooling water.

3.3 CHEMICAL CLEANING

A. Refill the system with water and allow for 10 volume percent of pre-cleaner for the removal of scale, oils and other extraneous materials. Add the required amount of cleaner and circulate for 6 to 8 hours at 150 degrees F, or 12 hours if less than 90 degrees Fahrenheit.

B. The system cleaner shall be INTERCLEAN MC-1 by Interstate Chemical Co., or approved equal.

C. Drain the system after the required circulation period as quickly as possible. This will prevent settling of foulants. Run circulating pumps and flush with clean water until the discharge water is clear.

D. When system water is clear, remove, clean and replace all strainers.

E. Fill the system with the approved glycol blend. All air vents should be opened during the filling process to ensure that the air is purged from the system. Once the system is full, all air vents should be closed.

F. Circulate the glycol water mixture for 24 hours before a sample is taken and tested for the proper concentration, freeze point, reserve alkalinity and pH.

END OF SECTION 232525
GLYCOL SOLUTIONS

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SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems. Metal ducts include the following:
1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
4. Double-wall round and flat-oval ducts and fittings.
5. Sheet metal materials.
7. Hangers and supports.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS

A. Product data including details of construction relative to materials, dimensions of individual components, profiles, and finishes for the following items:
1. Sealants and Gaskets.
3. Contractor’s Duct Fabrication Standards.

B. Sheet Metal Shop Drawings:
1. Layout Drawings: CAD-generated and drawn to 1/4 inch equals 1 foot (1:50) scale. Show fabrication and installation details for metal ducts.
   a. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
   b. Duct layout indicating sizes and pressure classes.
   c. Elevations of top and bottom of ducts.
   d. Dimensions of main duct runs from building grid lines.
   e. Fittings.
   f. Reinforcement and spacing.
   g. Seam and joint construction.
   h. Penetrations through fire-rated and other partitions.
   i. Equipment installation based on equipment being used on Project.
   j. Duct accessories, including access doors and panels.
   k. Hangers and supports, including methods for duct and building attachment, vibration isolation, and wind restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data:
1. Installer Qualifications:
   a. Welding certificates.
B. Field Quality Control Test Reports.

1.5 QUALITY ASSURANCE

A. Comply with the current edition of SMACNA's "HVAC Duct Construction Standards – Metal and Flexible." Where conflicts exist between SMACNA Standards and this Section, provide the more stringent option.

B. Welding: Qualify procedures and personnel according to:
   1. AWS D1.1, "Structural Welding Code-Steel," for hangers and supports

C. NFPA Compliance - Comply with current edition of:
   1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
   2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."


1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver sealant and fire-stopping materials to site in original unopened containers of bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, current time, and mixing instructions for multi-component materials.

B. Store and handle sealant and fire-stopping materials in compliance with manufacturers' recommendations to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

C. Deliver and store stainless steel sheets with mill-applied adhesive protective paper, maintained through fabrication and installation.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 (Z275) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

B. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.

C. Stainless Steel: ASTM A 480/A 480M, Type [316] [304], and having a No. 2D finish for concealed ducts and No. 4 finish for exposed ducts.


E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts. For other duct materials, provide reinforcing of compatible materials.

METAL DUCTS
F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.2 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Solids Content: Minimum 65 percent.
   5. Mold and mildew resistant.
   6. VOC: Maximum 75 g/L (less water).
   7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
   8. Service: Indoor or outdoor.
   10. Product shall be equivalent to Hardcast "Iron Grip 601."

C. Flanged Joint Sealant: Comply with ASTM C 920.
   2. Type: S.
   3. Grade: NS.
   5. Use: O.

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

E. Round Duct Joint O-Ring Seals:
   1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
   2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
   3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.3 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

E. Trapeze and Riser Supports:
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.4 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
   1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
   2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified:
      a. Ductmate Industries, Inc.
      b. Nexus Inc.
      c. Ward Industries, Inc.

C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified:
      a. Ductmate Industries, Inc.
      b. Lockformer.
   2. Duct Size: Maximum 30 inches (750 mm) wide and up to 2-inch wg (500-Pa) pressure class.
   3. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.

D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches (480 mm) and larger and 0.0359 inch (0.9 mm) thick or less, with more than 10 sq. ft. (0.93 sq. m) of nonbraced panel area.

2.5 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

A. Diameter as applied to flat-oval ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.

B. Round, Longitudinal- and Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards-Metal and Flexible."

C. Flat-Oval, Spiral Lock-Seam Ducts: Fabricate supply ducts according to SMACNA's "HVAC Duct Construction Standards-Metal and Flexible." Fabricate ducts larger than 72 inches (1830 mm) in diameter with butt-welded longitudinal seams.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified:
D. Duct Joints:
   1. Ducts up to 20 Inches (500 mm) in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
   2. Ducts 21 to 72 Inches (535 to 1830 mm) in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
   3. Ducts Larger Than 72 Inches (1830 mm) in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards-Metal and Flexible," Figure 3-2.
   4. Round Ducts: Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer's tolerances.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified:
         1) Ductmate Industries, Inc.
         2) Lindab, Inc.
   5. Flat-Oval Ducts: Prefabricated connection system consisting of two flanges and one synthetic rubber gasket.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified:
         1) Ductmate Industries, Inc.
         3) SEMCO Incorporated.

E. Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards-Metal and Flexible," with metal thicknesses two gauge numbers heavier than specified for longitudinal-seam straight ducts.

F. Elbows: Use die-formed, gored, pleated, or mitered construction with bend radius of 1-1/2 times duct diameter. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards-Metal and Flexible," with metal thickness two gauge numbers heavier than specified for longitudinal-seam straight ducts.

2.6 DOUBLE-WALL DUCT AND FITTING FABRICATION

A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified:
   1. Lindab, Inc.
   3. SEMCO Incorporated.

B. Ducts: Fabricate double-wall (insulated) ducts with an outer shell and an inner duct. Dimensions indicated are for inner ducts.
   1. Outer Shell: Base metal thickness on outer-shell dimensions. Fabricate outer-shell lengths 2 inches (50 mm) longer than inner duct and insulation and in metal thickness specified for single-wall duct.
2. Insulation: 2-inch- (50-mm-) thick fibrous glass, unless otherwise indicated. Terminate insulation where double-wall duct connects to single-wall duct or uninsulated components, and reduce outer shell diameter to inner duct diameter.
   a. Thermal Conductivity (k-Value): 0.26 at 75 deg F (0.037 at 24 deg C) mean temperature.
3. Solid Inner Ducts: Use the following sheet metal thicknesses and seam construction:
   a. Ducts up to 42 Inches (225 to 1070 mm) in Diameter: 0.028 inch (0.7 mm) with spiral-seam construction.
   b. Ducts 44 to 88 Inches (1120 to 2234 mm) in Diameter: 0.034 inch (0.85 mm) with spiral-seam construction.
4. Perforated Inner Ducts: Fabricate with 0.028-inch-0.7-mm- thick sheet metal having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent.
5. Maintain concentricity of inner duct to outer shell by mechanical means. Prevent dislocation of insulation by mechanical means.
C. Fittings: Fabricate double-wall (insulated) fittings with an outer shell and an inner duct.
   1. Solid Inner Ducts: Use the following sheet metal thicknesses:
      a. Ducts up to 34 Inches (75 to 865 mm) in Diameter: 0.028 inch (0.7 mm).
      b. Ducts 35 to 58 Inches (890 to 1475 mm) in Diameter: 0.034 inch (0.85 mm).
      c. Ducts 60 to 88 Inches (1525 to 2235 mm) in Diameter: 0.040 inch (1.0 mm).
   2. Perforated Inner Ducts: Fabricate with 0.028-inch- (0.7-mm-) thick sheet metal having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS
   A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
      2. Supply Ducts (Upstream of/Before Air Terminal Units): 4-inch wg (1000 Pa).
      3. Supply Ducts (Downstream of/After Air Terminal Units): 2-inch wg (500 Pa).
      5. Return Ducts (Negative, Low-Pressure): 2-inch wg (500 Pa).
      6. Return Ducts (Downstream of/After Air Terminal Units): 4-inch wg (1000 Pa).
      8. Laboratory Exhaust Ducts (Negative Pressure): 4 inch wg (1000 Pa) or associated exhaust fan total static pressure, whichever is more stringent.
   B. Material: Unless noted otherwise:
      1. All ducts shall be G90 galvanized steel.

3.2 DUCT INSTALLATION (GENERAL)
   A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round and flat-oval ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.


M. Paint interiors of ducts for 24 inches (600 mm) upstream of ducted registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized steel primer. Paint materials and application requirements are specified in Division 09 painting sections.

N. Install ducts with vibration controls. Refer to Division 23 Section "Vibration Controls for HVAC".

3.3 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.4 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

A. Install ducts to allow for thermal expansion through 2000 deg F (1110 deg C) temperature range.
B. Comply with NFPA-96.

C. Fabricate exposed ductwork of 18 gauge minimum thickness Type 304 stainless steel with finish to match kitchen equipment and kitchen hood. Weld all joints and seams.

D. Fabricate concealed ductwork of carbon steel sheet metal with thickness of 16 gauge for ducts 4 square feet in area or less and 14 gauge for ducts over 4 square feet. Weld all joints and seams.

E. Install kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.

F. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 12 feet (3.7 m) in horizontal ducts, and at every floor for vertical ducts, and as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches (38 mm) from bottom of duct.

G. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.5 ADDITIONAL INSTALLATION REQUIREMENTS FOR DISHWASHER HOOD EXHAUST DUCTWORK

A. Fabricate Dishwasher Hood Exhaust Ducts of 20 gauge minimum, Type 304, stainless steel with finish to match kitchen equipment. Weld all seams and joints.

3.6 ADDITIONAL INSTALLATION REQUIREMENTS FOR FUME HOOD AND LABORATORY EXHAUST DUCTWORK SYSTEMS.

A. General: This is all ductwork associated with laboratory exhaust fans and fume hood exhaust fans.

B. Use rectangular, round or flat oval ductwork with materials as follows:

1. Galvanized Steel: Exhaust ductwork shall be two (2) gauge numbers heavier than listed in SMACNA pressure class indicated, with 20 gauge minimum.
2. Stainless Steel: Exhaust ductwork shall be Type 304 with 2B mill finish for concealed areas and No. 4 finish for exposed ducts in finished areas. Exhaust ductwork shall be two (2) gauge numbers heavier than listed in SMACNA pressure class indicated, with 20 gauge minimum.

C. Seam and Joint Construction: All seams and joints in stainless steel ductwork shall be fully welded.

D. Comply with all requirements of the International Mechanical Code Section 510 "Hazardous Exhaust Systems":

1. Fabricate ductwork of minimum duct gauges as scheduled in Section 510.
2. Provide explosion relief.
3.7 EXTERIOR DUCTWORK
A. Protect all exterior surfaces of single and double wall insulated ductwork and associated equipment exposed to weather with a weatherproof and vapor barrier finish installed per manufacturer instructions. Exception is boiler stack breeching.
   1. Weatherproof and vapor barrier finish shall be equal to AlumaGuard 60 laminated jacketed system as manufactured by Polyguard Products, Inc. The laminated jacketing system shall be 60 mil thick, and shall consist of a rubberized bitumen compound, heat applied to a cross-laminated high strength polyethylene film, laminated to aluminum foil. Comply with duct sealing requirements prior to application.

3.8 SEAM AND JOINT SEALING
A. Seal duct seams and joints as follows:
   1. All transverse joints, longitudinal seams, and duct penetration (more stringent than SMACNA requirements).
B. Seal ducts before external insulation is applied.

3.9 HANGING AND SUPPORTING
A. Support horizontal ducts within 24 inches (600 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.
B. Support vertical ducts at maximum intervals of 8 feet (2.5 m) and at each floor.
C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
D. Install concrete inserts before placing concrete.
E. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
F. Support each duct elbow at downstream side of elbow with strap or trapeze.
G. Ductwork shall be independently supported from structure and support shall not be shared with other trades.

3.10 CONNECTIONS
A. Make connections to equipment with flexible connectors according to Division 23 Section "Air Duct Accessories."
B. Comply with SMACNA's "HVAC Duct Construction Standards-Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.11 FIELD QUALITY CONTROL
A. Test duct leakage on sections of ductwork or systems as described below:
   1. Test all ductwork rated at 3" WG or above, positive or negative pressure.
B. Perform the following field tests and inspections according to SMACNA’s "HVAC Air Duct Leakage Test Manual" and prepare test reports:

1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing to the Architect and Owner in writing.
3. Maximum Allowable Leakage: Comply with requirements for Leakage Class 2. Note: The maximum allowable leakage specified above exceeds the requirements of SMACNA’s ‘HVAC Air Duct Leakage Test Manual’. This project shall achieve these requirements because all transverse joints, longitudinal seams, and duct penetrations are sealed per this section.
4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

3.12 CLEANING NEW SYSTEMS

A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.

B. Use service openings, as required, for physical and mechanical entry and for inspection.

1. Create other openings to comply with duct standards.
2. Disconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling sections to gain access during the cleaning process.

C. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.

D. Clean the following metal duct systems by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts or duct accessories.

4. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

F. Cleanliness Verification:
   1. Visually inspect metal ducts for contaminants.
   2. Where contaminants are discovered, re-clean and re-inspect ducts.

3.13 CLEANING EXISTING SYSTEMS

A. Use service openings, as required, for physical and mechanical entry and for inspection.
   1. Use existing service openings where possible.
   2. Create other openings to comply with duct standards.
   3. Disconnect flexible ducts as needed for cleaning and inspection.
   4. Reseal rigid fiberglass duct systems according to NAIMA recommended practices.
   5. Remove and reinstall ceiling sections to gain access during the cleaning process.

B. Mark position of dampers and air-directional mechanical devices before cleaning, and restore to their marked position on completion.

C. Particulate Collection and Odor Control:
   1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron size (or larger) particles.
   2. When venting vacuuming system to the outside, use filtration to contain debris removed from HVAC system, and locate exhaust down wind and away from air intakes and other points of entry into building.

D. Clean the following metal duct systems by removing surface contaminants and deposits:
   1. Air outlets and inlets (registers, grilles, and diffusers).
   2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
   3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
   5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
   7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:
   1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
   2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
   3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts or duct accessories.
4. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

5. Provide operative drainage system for washdown procedures.

6. Biocidal Agents and Coatings: Apply biocidal agents if fungus is present. Apply biocidal agents according to manufacturer's written instructions after removal of surface deposits and debris.

F. Cleanliness Verification:

1. Verify cleanliness after mechanical cleaning and before application of treatment, including biocidal agents and protective coatings.

2. Visually inspect metal ducts for contaminants.

3. Where contaminants are discovered, re-clean and reinspect ducts.

G. Gravimetric Analysis: At discretion and expense of Owner, sections of metal duct system, chosen randomly by Owner, may be tested for cleanliness according to NADCA vacuum test gravimetric analysis.

1. If analysis determines that levels of debris are equal to or lower than suitable levels, system shall have passed cleanliness verification.

2. If analysis determines that levels of debris exceed suitable levels, system cleanliness verification will have failed and metal duct system shall be re-cleaned and re-verified.

H. Verification of Coil Cleaning: Cleaning must restore coil pressure drop to within 10 percent of pressure drop measured when coil was first installed. If original pressure drop is not known, coil will be considered clean only if it is free of foreign matter and chemical residue, based on thorough visual inspection.
PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes HVAC casings for field-erected air-handling systems and for housing mechanical equipment.

1.2 PERFORMANCE REQUIREMENTS
A. Static-Pressure Classes:
1. Upstream from Fan(s): 4-inch wg (1000 Pa).
2. Downstream from Fan(s): 4-inch wg (1000 Pa).
3. The final pressure class selected shall meet the requirements above the total static pressure of the fan served plus 1-inch wg.

B. Acoustical Performance:
1. STC: 40 according to ASTM E 90.

C. Structural Performance:
1. Casings shall be fabricated to withstand 133 percent of the indicated static pressure without structural failure. Wall and roof deflection at the indicated static pressure shall not exceed 1/8 inch per foot (0.97 mm per meter) of width.
   a. Fabricate outdoor casings to withstand wind load of 15 lbf/sq. ft. (720 N/sq. m) and snow load of 30 lbf/sq. ft. (1440 N/sq. m).

1.3 DEFINITIONS
A. Thermal Conductivity and Apparent Thermal Conductivity (k-Value): As defined in ASTM C 168. In this Section, these values are the result of the formula Btu x in./h x sq. ft. x deg F (W/m x K) at temperature differences specified. Values are expressed as Btu (W).
1. Example: Apparent Thermal Conductivity (k-Value): 0.26 (0.037).

1.4 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.5 ACTION SUBMITTALS
A. Product Data: For factory-fabricated casings, sealant materials, and acoustic liner materials.
B. Certification Letter: For factory-fabricated casings, signed by product manufacturer.
1. Show sound-absorption coefficients in each octave band lower than those scheduled when tested according to ASTM C 423.
2. Show airborne sound transmission losses lower than those scheduled when tested according to ASTM E 90.
C. Shop Drawings:
   1. Layout Drawings: Include plans, elevations, sections, components, and attachments to other work. Show fabrication and installation details of the following:
      a. Reinforcement and spacing.
      b. Seam and joint construction.
      c. Access doors, including frames, hinges, and latches.
      d. Filter, coil, humidifier, and other apparatus.
      e. Hangers and supports, including methods for building attachment, vibration isolation, and casing attachment.
      f. Interior lighting, including switches.

1.6 INFORMATIONAL SUBMITTALS
   A. Qualification Data:
      1. Installer Qualifications:
         a. Welding certificates.

1.7 QUALITY ASSURANCE

1.8 COORDINATION
   A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
   B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
      1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 GENERAL CASING FABRICATION REQUIREMENTS
   A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 6, "Equipment and Casings," for acceptable materials, material thicknesses, and casing construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
      1. Fabricate casings with more than 3-inch wg (750-Pa) negative static pressure according to SMACNA's "Rectangular Industrial Duct Construction Standards."
      2. Casings with more than 2-inch wg (500-Pa) positive static pressure may be fabricated according to SMACNA's "Rectangular Industrial Duct Construction Standards."
B. **Galvanized Sheet Steel:** Comply with ASTM A 653/A 653M.

1. **Exterior Surface Galvanized Coating Designation:** G210 (Z600).
2. **Interior Surface Galvanized Coating Designation:**
   a. Sections Not Exposed to Moisture: G90 (Z275).
   b. Sections Housing and Downstream from Cooling Coil and Humidifiers: Not allowed. Provide stainless steel.

C. **Stainless Steel:** ASTM A 480/A 480M, Type 304, and having a No. 2D finish.

D. **Factory- or Shop-Applied Antimicrobial Coating:**

1. Apply to the interior sheet metal surfaces of casing in contact with the airstream. Apply untreated clear coating to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H minimum when tested according to ASTM D 3363.
4. **Surface-Burning Characteristics:** Maximum flame-spread index of 25 and maximum smoke-developed index of 50 according to UL 723; certified by an NRTL.
5. **Applied Coating Color:** Standard.

E. **Reinforcement Shapes and Plates:** ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. **Sealing Requirement:** SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seal Class A. Seal all seams, joints, connections, and abutments to building.

G. **Penetrations:** Seal all penetrations airtight. Cover with escutcheons and gaskets, or fill with suitable compound so there is no exposed insulation. Provide shaft seals where fan shafts penetrate casing.

H. **Access Doors:** Fabricate access doors according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 6-11, "Casing Access Doors - 2-inch wg (500 Pa)," and Figure 6.12, "Casing Access Doors - 3-10-inch wg (750-2500 Pa); and according to pressure class of the plenum or casing section in which access doors are to be installed.

1. **Size:** Minimum 20 by 54 inches (500 by 1370 mm).
2. **Vision Panel:** Double-glazed, wire-reinforced safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
3. **Hinges:** Piano or butt hinges and latches, number and size according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
4. **Latches:** Minimum of two wedge-lever-type latches, operable from inside and outside.
5. Neoprene gaskets around entire perimeters of door frames.
6. Doors shall open against air pressure.

2.3 **SHOP-FABRICATED CASINGS**

A. **Single- and Double-Wall Casings:** Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.

B. **Double-Wall Casing Inner Panel:** Perforated, galvanized sheet steel having 3/32-inch-(2.4-mm-) diameter perforations, with overall open area of [23] <Insert number> percent. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.
C. Double-Wall Casing Inner Panel: Solid sheet steel. Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.

D. Interstitial Insulation: Polyurethane foam complying with NFPA 90A or NFPA 90B.

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   1. Maximum Thermal Conductivity: \[0.27 \text{ Btu} \times \text{in./h} \times \text{sq. ft.} \times \text{deg F} \times (0.039 \text{ W/m} \times \text{K})\] at 75 deg F (24 deg C) mean temperature.
   2. Coat insulation with antimicrobial coating.
   3. Cover insulation with polyester film complying with UL 181, Class 1.

F. Interstitial Insulation: Flexible-elastomeric duct liner complying with ASTM C 534, Type II for sheet materials and with NFPA 90A or NFPA 90B.
   1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature.

G. Fabricate casings with standing seams and angle-iron reinforcements unless otherwise indicated.

H. Fabricate close-off sheets from casing to dampers, filter frames, and coils and between stacked coils. Use galvanized sheet steel of same thickness as casing and with a galvanized coating designation of G90 (Z275).

I. Bolt close-off sheets to frame flanges and housings. Support coils on stands fabricated from galvanized-steel angles or channels.

J. Reinforce casings with galvanized-steel angles.

2.4 MANUFACTURED CASINGS

A. Description: Double-wall, insulated, pressurized equipment casing.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Acoustical Surfaces, Inc.
   2. Buffalo Air Handling.
   3. CertainTeed Corp.; Insulation Group.
   4. Industrial Noise Control, Inc.
   5. McGill AirSilence LLC.
   6. SEMCO Incorporated.

C. Double-Wall Panel Fabrication: Solid, galvanized sheet steel exterior wall and solid, galvanized sheet steel interior wall; with space between wall filled with insulation.
   1. Wall Thickness: 2 inches (50 mm).
   2. Fabricate with a minimum number of joints.
   3. Weld exterior and interior walls to perimeter; to interior, longitudinal, galvanized-steel channels; and to box-end internal closures. Paint welds.
   4. Sheet metal thickness shall comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" for static-pressure class indicated for casing.
5. **Sheet Metal Thicknesses:**
   a. Exterior Wall Thickness: 0.040 inch (1.0 mm) minimum.
   b. Interior Wall Thickness: 0.034 inch (0.85 mm) minimum.

6. **Double-Wall Casing Inner Panel:** Solid sheet steel or perforated galvanized steel.

7. Fill each panel assembly with insulating material that is noncombustible, inert, mildew resistant and vermin proof and that complies with NFPA 90A.

8. Fabricate panels with continuous tongue-and-groove or self-locking joints effective inside and outside each panel.

D. **Trim Items:** Fabricate from a minimum of 0.052-inch (1.3-mm) galvanized sheet steel, furnished in standard lengths for field cutting.

2.5 **CASING LINER**

A. **Fibrous-Glass Liner:** Comply with ASTM C 1071, NFPA 90A, or NFPA 90B and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

   1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corp.; Insulation Group.
      b. Johns Manville.
      c. Knauf Insulation.
      d. Owens Corning.

   2. **Maximum Thermal Conductivity:**
      a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
      b. Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K) at 75 deg F (24 deg C) mean temperature.

   3. **Antimicrobial Erosion-Resistant Coating:** Apply to surface of the liner that will form the interior surface of casing to act as a moisture repellent and an erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.

   4. **Solvent-Based Liner Adhesive:** Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
      a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. **Flexible-Elastomeric Casing Liner:** Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1, and with NFPA 90A or NFPA 90B.

   1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
      a. Aeroflex USA Inc.
      b. Armacell LLC.

   2. **Surface-Burning Characteristics:** Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
   a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Insulation Pins and Washers:
1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, stainless steel, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

D. Shop or Factory Application of Casing Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."
1. Adhere a single layer of indicated thickness of casing liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of casing liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of casings or cut and fit to ensure butted-edge overlapping.
5. Apply adhesive coating on longitudinal seams in casings with air velocity of 2500 fpm (12.7 m/s).
6. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
7. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from casing wall. Fabricate edge facings at the following locations:
   a. Fan discharges.
   b. Intervals of lined casing preceding unlined duct.
   c. Upstream edges of transverse joints in casings where air velocities are higher than 2500 fpm (12.7 m/s) or where indicated.
8. Secure insulation between perforated sheet metal inner wall of same thickness as specified for outer wall. Use mechanical fasteners that maintain inner wall at uniform distance from outer wall without compressing insulation.

2.6 SEALANT MATERIALS
A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Solvent-Based Joint and Seam Sealant:
1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
7. Mold and mildew resistant.
8. VOC: Maximum 395 g/L.
9. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
10. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
11. Service: Indoor or outdoor.
12. Substrate: Compatible with galvanized sheet steel or stainless steel.

C. Flanged Joint Sealant: Comply with ASTM C 920.
   2. Type: S.
   3. Grade: NS.
   5. Use: O.
   6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.7 SHEET METAL MATERIALS
A. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 (Z275) coating or other designation indicated above; ducts shall have mill-phosphatized finish for surfaces exposed to view.
B. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet steel casings.
C. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).
D. Miscellaneous Materials and Products: Types and sizes required to comply with HVAC casing system requirements, including proper connection of ducts and equipment.

2.8 SEALANT MATERIALS
A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.
B. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.
C. Solvent-Based Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.
D. Flanged Joint Mastics: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
E. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.9 SHOP- AND FIELD-FABRICATED CASINGS
A. Fabricate casings according to SMACNA's "Rectangular Industrial Duct Construction Standards."
B. Shop fabricate casings, to greatest extent possible, with a minimum number of joints and to minimize field fabrication and assembly.

C. Fabricate casings with standing seams and angle reinforcements. Fabricate close-off sheets from casing sides, top, and bottom to damper, coil, and filter frames. Fabricate close-off sheets at joints between stacked coils. Bolt close-off sheets to frame flanges and housings. Support coils on stands fabricated from galvanized-steel angles or channels.

D. Reinforce casings with galvanized- or painted-steel angles.

E. Seal joints with liquid-type, high-pressure duct sealant to eliminate air leakage.

F. Fabricate drain pans for cooling coils, humidifiers, and eliminator blade sections in casings with external connections and vented deep-seal traps for drainage piping with 3/4-inch (20-mm) pipe connections. Fabricate and reinforce drain pans of same material and thickness as housing, 2 inches (50 mm) deep with rolled edges. Solder seams.

G. Fabricate casings with reinforced openings for access doors at least 20 inches (500 mm) wide by 48 inches (1200 mm) high and located for access to each item of equipment housed. Refer to Division 23 Section "Air Duct Accessories" for access doors.

H. Fabricate casings to receive flexible or outlet connectors for fans. Refer to Division 23 Section "Air Duct Accessories" for flexible connectors.

I. Static-Pressure Classifications: Unless otherwise indicated, fabricate HVAC casings according to the following:
   1. Upstream from Fan(s): 4-inch wg (1000 Pa).
   2. Downstream from Fan(s): 4-inch wg (1000 Pa).
   3. The final pressure class selected shall meet the requirements above the total static pressure of the fan served plus 1-inch wg.

2.10 FACTORY-FABRICATED CASINGS

A. Description: Double-wall, insulated, pressurized equipment casing.
   1. Manufacturer:

B. Panel Fabrication: Solid, galvanized sheet steel exterior shell and [solid] [perforated], galvanized sheet steel interior shell; with 2- or 4-inch (50- or 100-mm) space between shells, as indicated.
   1. Fabricate with a minimum number of joints.
   2. Weld exterior and interior shells to perimeter; to interior, longitudinal, galvanized-steel channels; and to box-end internal closures. Paint welds.
   3. Exterior Shell Thickness: 0.040 inch (1.0 mm) minimum.
   4. Interior Shell Thickness: 0.034 inch (0.85 mm) minimum.
   5. Interior Shell Thickness: 0.034 inch (0.85 mm) minimum, with 3/32-inch (2.4-mm) perforations at 3/16-inch (5-mm) staggered spacing for 23 percent open area.
   6. Fabricate perimeter and interior, longitudinal channel members with galvanized-steel shapes.
   7. Fill each panel assembly with insulating material that is noncombustible, inert, mildew resistant, and vermin proof, and that complies with NFPA 90A.
   8. Fabricate panels with tongue-and-groove, continuous self-locking joints effective inside and outside each panel.
C. Trim Items: Fabricate from a minimum of 0.052-inch (1.3-mm) galvanized sheet steel, furnished in standard lengths for field cutting.

D. Access Doors: Fabricate personnel access doors at least 24 by 60 inches (600 by 1500 mm) and other access doors in sizes indicated.
   1. Fabricate doors of same thickness as panels, with a minimum 0.040-inch (1.0-mm) solid, interior and exterior, galvanized sheet steel shell.
   2. Install a minimum of two ball-bearing hinges and two wedge-lever-type latches, operable from inside and outside. Install doors to open against air pressure differential. Install neoprene gaskets around entire perimeters of door frames.
   3. Fabricate windows in doors consisting of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.

E. Structural Performance: Fabricate plenum to be self-supporting and capable of withstanding internal static pressures as scheduled, without any panel joint exceeding deflection of L/200 where "L" is the unsupported span length within completed casings.
   1. Fabricate outdoor casings to withstand wind load of 15 lbf/sq. ft. (720 N/sq. m) and snow load of 30 lbf/sq. ft. (1440 N/sq. m).
   2. Acoustic Performance: Certified by an independent acoustical testing agency listing sound-absorption and transmission-loss characteristics of panel assemblies.
   3. Thermal Conductivity (k-Value): 0.26 at 75 deg F (0.037 at 24 deg C) mean temperature.

F. Static-Pressure Classifications: Unless otherwise indicated, fabricate HVAC casings according to the following:
   1. Upstream from Fan(s): 4-inch wg (500 Pa).
   2. Downstream from Fan(s): 4-inch wg (1500 Pa).
   3. The final pressure class selected shall meet the requirements above the total static pressure of the fan served plus 1-inch wg.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine concrete bases and roof curbs for compliance with requirements for conditions affecting installation and performance of HVAC casings.
   B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
   A. Install casings according to SMACNA's "HVAC Duct Construction Standards-Metal and Flexible." Comply with recommended spacing of sheet metal screws and with requirements for casing sealing and trim positioning.
   B. Apply sealant to joints, connections, and mountings.
   C. Field-cut openings for pipe and conduit penetrations; insulate and seal according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
   D. Support casings on floor or foundation system. Secure and seal to base.
   E. Support components rigidly with ties, braces, brackets, restraints, and anchors of types that will maintain housing shape and prevent buckling.
F. Comply with requirements of Division 23 Section "Vibration Controls for HVAC" for vibration isolation and wind restraints.

G. Align casings accurately at connections, with 1/8-inch (3-mm) misalignment tolerance and with smooth interior surfaces.

H. Maintain duct seal class integrity throughout casings.

3.3 LINER INSTALLATION

A. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

B. Apply adhesive to liner that faces direction of airflow not receiving metal nosing.

C. Butt transverse joints without gaps and coat joint with adhesive.

D. Fold and compress liner in corners of casings or cut and fit to ensure butted-edge overlapping.

E. Do not apply liner with longitudinal joints, except at corners of casings, unless casing size and standard liner product dimensions make longitudinal joints necessary.

F. Apply adhesive coating on longitudinal seams in casings.

G. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.

H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profile or are integrally formed from casing wall. Fabricate edge facings at the following locations:
   1. Fan discharges.
   2. Intervals of lined casing preceding unlined casing.
   3. Upstream edges of transverse joints in casings.

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:
   1. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days’ advance notice for testing.
   2. Determine leakage from entire system or section of system by relating leakage to surface area of test section. Comply with requirements for leakage classification of ducts connected to casings.
   3. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

END OF SECTION 233119
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Backdraft dampers.
   2. Volume dampers.
   3. Pressure-relief doors.
   4. Motorized control dampers.
   5. Fire dampers.
   6. Ceiling fire dampers.
   7. Smoke dampers.
   8. Combination fire and smoke dampers.
  10. Turning vanes.
  11. Duct-mounting access doors.
  12. Flexible connectors.
  13. Flexible ducts.
  14. Duct accessory hardware.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Backdraft dampers.
   2. Volume dampers.
   3. Pressure Relief doors.
   4. Motorized control dampers.
   5. Fire dampers.
   6. Ceiling fire dampers.
   7. Smoke dampers.
   8. Combination fire and smoke dampers.
  10. Turning vanes.
  11. Duct-mounting access doors.
  12. Flexible connectors.
  13. Flexible ducts.

B. Shop Drawings:
   1. Layout Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
      a. Special fittings.
c. Motorized-control damper installations.
d. Fire-damper, smoke-damper, and combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.

2. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

1.4 QUALITY ASSURANCE


1.5 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to [10] <Insert number> percent of amount installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards-Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 (Z275) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless Steel: ASTM A 480/A 480M.


F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

AIR DUCT ACCESSORIES

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2.3 BACKDRAFT DAMPERS

A. Manufacturers:
   1. Air Balance, Inc.
   2. Ductmate.
   3. Duro Dyne Corp.
   5. Penn Ventilation Company, Inc.
   6. Pottorff.
   7. Prefco Products, Inc.
   8. Ruskin Company.

B. Description: Multiple-blade, parallel action gravity balanced, with center-pivoted blades of maximum 6-inch (150-mm) width, with sealed edges, assembled in rattle-free manner with 90-degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.

C. Frame: 0.063-inch thick extruded aluminum, with welded corners and mounting flange.

D. Blades: 0.050-inch thick aluminum sheet.

E. Blade Seals: Neoprene.

F. Blade Axles: Galvanized steel.

G. Tie Bars and Brackets: Galvanized steel.

H. Return Spring: Adjustable tension.

2.4 PRESSURE RELIEF DOORS

A. Manufacturers:
   1. Greenheck.
   2. Nailor Industries, Inc.
   3. Ruskin Company.

B. Pressure Relief Setting: Select pressure relief setting to duct pressure class.

C. Frame: Minimum 12 gage (2.8 mm) galvanized steel, Z-shaped.

D. Door:
   2. Material: Minimum 12 gage (2.8 mm) galvanized steel.

E. Springs: Stainless steel negator springs.

F. Seals: Polyurethane foam around door perimeter.

G. Pressure Relief Mechanism: Exposed on face of door.

H. Mounting: Vertical.

I. Performance Data:
   1. Temperature Rating: Withstand maximum 250 degrees F (121 degrees C).
2. Capacity: Demonstrate capacity of pressure relief door to operate according to HVAC system operating conditions.
   a. Pressure Relief Settings: 3 to 10 inches w.g. (0.7 to 2.5 kPa) based upon a 24 inch (610) by 12 inch (305) damper @ 17” w.g. pressure.
   b. Relief Airflow: Maximum air volume of 15,000 cubic feet per minute (425 m3/min) based upon a 24 inch (610) by 12 inch (305) damper @ 17” w.g. pressure.

2.5 VOLUME DAMPERS

A. Manufacturers:
   1. Air Balance, Inc.
   2. Flexmaster U.S.A., Inc.
   5. METALAIRE, Inc.
   7. Penn Ventilation Company, Inc.
   8. Ruskin Company.

B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.
   1. Pressure Classes of 3-Inch wg (750 Pa) or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.

C. Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating and suitable for horizontal or vertical applications.
   1. Steel Frames: galvanized or stainless sheet steel channels, minimum of 16 gauge (1.55 mm) thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
   2. Roll-Formed Steel Blades: 16 gauge (1.55-mm-) thick, galvanized or stainless sheet steel.
   3. Aluminum Frames: 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
   4. Roll-Formed Aluminum Blades: 14 gauge (2.0-mm-) thick aluminum sheet, airflow shape.
   5. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum, airfoil shape.
   7. Bearings: Oil-impregnated bronze thrust or ball.
   8. Blade Seals: Neoprene, Silicone, or EPDM.
   10. Tie Bars and Brackets: Galvanized steel or Stainless Steel.

D. Jackshaft: 1-inch- (25-mm-) diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
   1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.
E. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch-(2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut. Include center hole to suit damper operating-rod size. Provide elevated platform for insulated duct mounting.

2.6 MOTORIZED CONTROL DAMPERS

A. Manufacturers:
   1. Duro Dyne Corp.
   2. Greenheck.
   5. Penn Ventilation Company, Inc.
   6. Pottorff.
   7. Ruskin Company.

B. General Description: AMCA-rated, opposed-blade design; minimum of 0.1084-inch- (2.8-mm-) thick, galvanized-steel frames with holes for duct mounting; minimum of 0.0635-inch- (1.61-mm-) thick, galvanized-steel damper blades with maximum blade width of 8 inches (203 mm).
   1. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
   2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
   3. Provide opposed-blade design with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm per sq. ft. (51 L/s per sq. m) of damper area, at differential pressure of 4-inch wg (995 Pa) when damper is being held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

2.7 FIRE, SMOKE, AND COMBINATION FIRE/SMOKE DAMPERS

A. Manufacturers:
   1. Greenheck.
   2. Nailor Industries, Inc.
   3. Pottorff.
   4. Ruskin Company.

B. Fire Dampers:
   1. For galvanized steel ductwork all components of the fire dampers shall be galvanized. All fire dampers located in stainless steel ductwork shall be 304 stainless steel including all components, unless otherwise indicated.
   2. Free area of the fire damper must be equal to the full area of the duct in which it is to be installed (Type C).
   3. All fire dampers shall meet the requirements of NFPA 80, 90A, and 101 and further shall be tested, rated, and labeled in accordance with the latest edition of UL Standard 555.
   4. Each fire damper shall be rated to close against 4 inch w.g. maximum pressure across the closed damper. If wall, floor or partition has a fire resistance rating of 3 hours or more, the fire damper shall have a UL 555 fire rating of 3 hours. All other fire dampers shall have a UL 555 rating of 1-1/2 hours. Each fire damper shall be equipped with a 165 degree F fusible link.
5. In duct systems designed to a SMACNA pressure class of 3 inch w.g. or higher, or which require SMACNA duct seal classes A or B, fire dampers shall also be type C with enclosures sealed by the manufacturer for high pressure. Contractor shall be responsible for any additional sealing of duct collars and connections required to maintain the specified SMACNA duct seal class requirements.

6. Dynamic fire Dampers: In addition to the requirements stated above, dynamic fire dampers shall be spring closure type that are Dynamic Rated for closure against maximum design airflow in all six installation configurations (ducted and unducted, vertical, and horizontal with airflow up and down).


C. Ceiling Fire Dampers:

1. Ceiling radiation dampers shall meet the requirements of NFPA 90-A and 101 and further shall be tested, rated, and labeled in accordance with the latest edition of UL Standard 555-C. All ceiling radiation dampers shall be UL Listed to protect supply, return, or exhaust air openings in the ceiling membrane of fire rated ceiling/floor and ceiling/roof assemblies in accordance with their listing in the UL Fire Resistance Directory. Ceiling radiation dampers shall have a UL fire resistance rating at least equal to the rating of the ceiling/floor or roof assembly that it protects, and a minimum UL fire resistance rating of 3 hours. UL qualification shall include use of thermal insulating blanket material where actual ceiling openings exceeds the size of the installed ceiling radiation damper as when used with recessed mount or lay-in style ceiling diffusers. Ceiling radiation dampers (when used in conjunction with thermal insulating blanket) shall be UL rated to protect ceiling opening up to 576 sq. inches.

2. Each ceiling radiation damper shall be equipped with a fusible link rated at 165/212/286 degree F that can be easily replaced from below the ceiling with access through the air device. Dampers with fusible links located between damper blades in a manner that makes them difficult to reach from below are not acceptable.

3. Ceiling radiation dampers may be manufactured and installed as a separate component or supplied and installed as an integral part of the air device. If supplied as a separate component, the damper shall be compatible in all respects with its associated air device, and if supplied as an integral component, the entire air device assembly shall comply with these specifications.

4. Dampers shall be equal to: Greenheck Model CRD, Ruskin Model CFD.

D. Smoke Dampers: Provide smoke dampers with the following features:

1. Smoke dampers and actuators shall meet the requirements of NFPA 92A, 92B, 101, 105 and further shall be tested, rated, and labeled as a “Leakage Rated Damper for Use in Smoke Control Systems” in accordance with the latest edition of UL 555S Leakage Class I (maximum leakage of 4 cfm per sq. ft. at 1 inch w.g. and 8 cfm per sq. ft. at 4 inch w.g.) and shall have a UL 555S elevated temperature rating of 350 degree F. minimum. Leakage ratings shall be for airflow in either direction through the damper. Each smoke damper/actuator combination shall be UL 555S rated to operate at maximum design airflow at its installed location. Each smoke damper shall be supplied with appropriate damper actuators installed by the damper manufacturer at the time of damper fabrication. Damper actuators shall be electric type. Coordinate voltage requirements with Division 26. Damper frame shall be galvanized steel formed into a structural hat channel shape with reinforced corners.
a. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

b. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.

c. Spring-Return Motors: Equip with an integral spiral-spring mechanism. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).

d. Outdoor Motors and Motors in Outside-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 degrees F (minus 40 degrees C).

e. Smoke dampers shall be provided with 24 VAC damper actuators. Line voltage damper actuators are not allowed.

2. In duct systems up to 2 inches water gauge damper blades shall be single skin 16 ga. minimum galvanized steel with three longitudinal grooves for reinforcement.

3. Each damper actuator shall be equipped with an open or closed indication feature consisting of two SPDT switches linked directly to the damper blade. One switch shall activate at the damper open position and the other shall activate at the damper closed position.

4. In duct systems 3 inches water gauge and above damper blades shall be of the airfoil type and shall have an equivalent metal thickness of 14 ga.

5. Bearings shall be sintered bronze sleeve type turning in extruded holes in the frame. Blade edge seals shall be silicone rubber designed to inflate and provide a tighter seal against leakage as pressure on either side of the damper increases. Jamb seals shall be flexible stainless steel compression type. Blades shall be completely symmetrical relative to their axle pivot point, presenting identical resistance to airflow in either direction or pressure on either side of the damper. Dampers must be rated for mounting vertically (with blades running horizontal) or horizontally and be UL 555S rated for leakage and airflow in either direction through the damper.

6. Dampers shall be equal to: Greenheck Models SMD-201/SMD-301 or Ruskin Model SD-37/SD-60.

E. Combination Fire Smoke Dampers: Provide combination smoke and fire dampers with the following features:

1. Combination smoke and fire dampers shall incorporate all of the applicable qualifications previously specified for the fire dampers and the smoke dampers and additionally shall meet the following requirements. Combination fire smoke dampers shall be manufactured with a metal sleeve of appropriate length and thickness for the required damper installations the damper actuator shall be installed by the damper manufacturer on the sleeve exterior.

2. Each combination smoke and fire damper shall be equipped with a temperature limited reopenable feature providing the following operational sequence. Temperature at the damper reaches 165 degrees F and the primary heat sensing device closes damper. Remote or local override command panel can then reopen damper. If temperature at damper reaches 350 degrees F, secondary heat sensing device will override command panel and close damper. Further override and reopening above this secondary temperature is not permitted. The damper open or close indication feature must also be supplied when this option is selected.

3. Each combination fire smoke damper shall be equipped with a 286 degree F fusible link allowing system operation for smoke control purpose during the early phase of a fire emergency.
4. Dampers shall be equal to: Greenheck Model FSD-211/FSD-311, Ruskin Model FSD-37/FSD-60.

5. Spring-Return Motors: Equip with an integral spiral-spring mechanism. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).

2.8 DUCT SILENCERS

A. Manufacturers:
   1. Industrial Acoustics Company.
   2. Price
   3. Ruskin Company.

B. General Description: Factory-fabricated and -tested, round or rectangular silencers with performance characteristics and physical requirements as indicated.

C. Fire Performance: Adhesives, sealants, packing materials, and accessory materials shall have fire ratings not exceeding 25 for flame-spread index and 50 for smoke-developed index when tested according to ASTM E 84.

D. Rectangular Units: Fabricate casings with a minimum of 0.034-inch- (0.85-mm-) thick, solid galvanized sheet metal for outer casing and 0.022-inch- (0.55-mm-) thick, ASTM A 653/A 653M, G90 (Z275), perforated galvanized sheet metal for inner casing.
   1. Provide galvanized and/or stainless steel casing thickness to meet project requirements for breakout noise control or cession control.

E. Round Units:
   1. Outer Casings:
      b. Up to 24 Inches (600 mm) in Diameter: 0.034 inch (0.85 mm) thick.
      c. 26 through 40 Inches (660 through 1000 mm) in Diameter: 0.040 inch (1.0 mm) thick.
      d. 42 through 52 Inches (1060 through 1300 mm) in Diameter: 0.052 inch (1.3 mm) thick.
      e. 54 through 60 Inches (1370 through 1500 mm) in Diameter: 0.064 inch (1.62 mm) thick.
      f. Provide galvanized and/or stainless steel casing thickness to meet project requirements for breakout noise control or cession control.
      g. Casings fabricated of spiral lock-seam duct may be one size thinner than that indicated.

   2. Interior Casing, Partitions, and Baffles:
      b. At least 0.034 inch (0.85 mm) thick and designed for minimum aerodynamic losses.

F. Sheet Metal Perforations: 1/8-inch (3-mm) diameter for inner casing and baffle sheet metal.

G. Fill Material: Moisture-proof nonfibrous material.
   1. Erosion Barrier: Polymer bag enclosing fill and heat-sealed before assembly.
H. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations.
   1. Do not use nuts, bolts, or sheet metal screws for unit assemblies.
   2. Lock form and seal or continuously weld joints.
   3. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
   4. Reinforcement: Cross or trapeze angles for rigid suspension.

I. Source Quality Control:
   1. Acoustic Performance: Test according to ASTM E 477.
   2. Record acoustic ratings, including dynamic insertion loss and self-noise power levels with an airflow of at least 2000-fpm (10-m/s) face velocity.
   3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch w.g. (1500-Pa) static pressure, whichever is greater.

J. Aerodynamic Performance: Provide silencers with static pressure loss equal to or less than that scheduled, not including system effects, tested in accordance with ASTM E477-99.
   1. The manufacturer shall provide Computational Fluid Dynamics (CFD) aerodynamic analysis of the silencer as indicated as indicated in the silencer schedule. The analysis shall include the attached ductwork, a minimum of 5 equivalent duct diameters up and downstream of the silencer, as shown on the drawings, to determine silencer pressure drop, including system effects, at design airflow. The manufacturer must report the selection of CFD parameters, including mesh type, mesh size, boundary conditions, convergence criteria, and turbulence model.

K. Certification: Provide certified test data on Dynamic Insertion Loss, Self-Noise Power Levels, and Aerodynamic Performance. Conduct all rating tests at same facility with the same silencer. Testing facility shall be accredited for ASTM E477-99 by the National Voluntary Laboratory Accreditation Program (NVLPA). Certificate of NVLAP accreditation shall accompany certified test reports. Open testing facility for inspection by Architect/Engineer if requested.
   1. The manufacturer shall test the silencer(s) as indicated in the silencer schedule. The engineer shall be notified of the test date at least two weeks in advance and the test may be witnessed by the engineer. Test shall show compliance with the project criteria and is subject to engineer approval.

2.9 TURNING VANES

A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards-Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Turning vanes are not allowed in return or exhaust ductwork.

C. Manufactured Turning Vanes: Fabricate 1-1/2-inch- (38-mm-) wide, double-vane, curved blades of galvanized sheet steel set 3/4 inch (19 mm) o.c.; support with bars perpendicular to blades set 2 inches (50 mm) o.c.; and set into vane runners suitable for duct mounting.
   1. Manufacturers:
      a. Ductmate Industries, Inc.
      b. Duro Dyne Corp.
      c. Ward Industries, Inc.
2.10 DUCT-MOUNTING ACCESS DOORS

A. Manufacturers:
1. Ductmate Industries, Inc.
2. Flexmaster U.S.A., Inc.
5. Nailor Industries, Inc.
6. Pottorff.
7. Ventfabrics, Inc.

B. General Description: Fabricate doors airtight and suitable for duct pressure class.

C. Door (Rectangular Duct): Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Provide 1-by-1-inch (25-by-25-mm) piano hinge and cam latches.
   1. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
   2. Provide number of hinges and locks as follows:
      a. Up to 18 Inches (450 mm) Square: Two hinges and two sash locks.
      b. Up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches with outside and inside handles.
      c. Sizes 24 by 48 Inches (600 by 1200 mm) and Larger: One additional hinge.

D. Pressure Relief Access Door: Double wall and duct mounting; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class and specified insulation. Include latches and retaining chain.
   1. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

E. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

F. Insulation: 1-inch- (25-mm-) thick, fibrous-glass or polystyrene-foam board.

2.11 FLEXIBLE CONNECTORS

A. Manufacturers:
1. Ductmate Industries, Inc.
2. Duro Dyne Corp.
3. Ventfabrics, Inc.

B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Select metal compatible with ducts.

   1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
   2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
   1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).
   2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
   3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).

   1. Minimum Weight: 16 oz./sq. yd. (542 g/sq. m).
   2. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and 185 lbf/inch (32 N/mm) in the filling.
   3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

   1. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).
   2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
   3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

2.12 FLEXIBLE DUCTS

A. Manufacturers:
   1. Flexmaster U.S.A., Inc.
   2. Hart & Cooley, Inc.
   4. Atco UPC #039
   5. Thermoflex M-KE

B. Type II (for final connection to air terminals and air outlets):
   1. Provide flexible ducts of two ply black polyester inner core mechanically locked without adhesives to a corrosion resistant galvanized steel helix. Inner core shall be covered by R-6.0 fiberglass insulation of one pound density. The fiberglass shall be covered with a 2.5 mil polyethylene vapor barrier.
   2. Duct shall meet the latest requirements of UL Standard 181, Class 1 flexible air duct and NFPA 90A. Duct to be rated for minimum of 6 inches positive pressure for duct sizes less than or equal to 12 inches diameter.
   3. Maximum Flame Spread: 25
   4. Maximum Smoke Developed: 50
   5. Vapor Transmission: 0.05 perms
   6. Duct shall be equal to Flexmaster Type 4B.

C. Flexible Duct Clamps:
   1. For connection of inner liner: Panduit strap in accordance with SMACNA installation standards.
   2. To secure outer jacket: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 through 18 inches (75 to 450 mm) to suit duct size.
2.13 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards—Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers on exhaust ducts nearest to outside and where indicated.

D. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

E. Provide volume dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.

F. Provide test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers, with fusible links, according to manufacturer's UL-approved written instructions.
   1. Provide suitable access to each damper to allow inspection, cycling or testing of the damper, and replacement of the fusible links when required. This includes furnishing and installing duct doors and wall or ceiling access panels as may be required. Division 23 shall be responsible for these access doors and panels unless they are specifically shown to be supplied by other trades.
   2. Provide fire dampers in all transfer openings and ducts passing through or penetrating fire rated partitions, walls and floors.
      a. Provide dynamic rated fire dampers where fire dampers are required as part of engineered smoke control systems.
   3. Provide smoke dampers in all transfer openings and ducts passing through smoke partitions.
   4. Provide combination smoke and fire dampers in all transfer openings and duct passing through combination smoke and fire rated walls.

H. Install duct silencers rigidly to ducts.

I. Install turning vanes in all square or rectangular 90 degree elbows and bullhead tee's for supply ductwork only.

J. No turning vanes shall be installed in return and exhaust ducts. For elbows in return and exhaust ducts, install a splitter when the radius of the elbow is less than 1.5 times throat radius in accordance with SMACNA Standards. Install a duct access door adjacent to the elbow for inspection and cleaning.
K. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows. Obtain written approval of Owner for location, size and type of all access doors after construction is complete which affects accessibility.

1. On inlet side of duct coils.
2. Upstream from motorized dampers, for access to damper motor and linkage.
3. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
4. Smoke detectors.
5. Upstream and downstream of humidifiers
6. Adjacent to louvers for cleaning and inspection

L. Install the following sizes for duct-mounting, rectangular access doors:

1. One-Hand or Inspection Access: 12 by 12 inches.
3. Head and Hand Access: 18 by 18 inches.

M. Install the following sizes for duct-mounting, round access doors:

1. One-Hand or Inspection Access: 10 inches (250 mm) in diameter.
2. Two-Hand Access: 10 inches (250 mm) in diameter.
3. Head and Hand Access: 16 inches (410 mm) in diameter.
4. Head and Shoulders Access: 18 inches (460 mm) in diameter.
5. Body Access: 24 inches (600 mm) in diameter.

N. Install the following sizes for duct-mounting, pressure relief access doors:

1. One-Hand or Inspection Access: 10 inches (250 mm) in diameter.
2. Two-Hand Access: 10 inches (250 mm) in diameter.
3. Head and Hand Access: 16 inches (410 mm) in diameter.
4. Head and Shoulders Access: 18 inches (460 mm) in diameter.

O. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment."

P. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

Q. For fans developing static pressures of 5-inch w.g. (1250 Pa) and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

R. Connect terminal units to supply ducts directly or with maximum 12-inch (300-mm) lengths of Type I flexible duct. Do not use flexible ducts to change directions.

S. Connect diffusers to low pressure ducts directly or with maximum 60-inch (1500-mm) lengths of Type II flexible duct clamped or strapped in place.

T. Connect flexible ducts to metal ducts as detailed on the drawings.

U. Install duct test holes where indicated and required for testing and balancing purposes.

3.2 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.
C. Final positioning of manual-volume dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

D. All access locations shall be walked with the owner prior to turnover for signoff. If access is not sufficient, modify as required to ensure proper access.

3.3 TESTING

A. Provide acceptance testing of all fire dampers, smoke dampers and combination fire/smoke dampers in compliance with NFPA Standard 80, latest edition, and the Authority Having Jurisdiction,

B. Provide additional training of Owner’s staff by physically identifying the location of all fire dampers, smoke dampers and combination fire/smoke dampers. Such training shall be eleven (11) months after the beginning of warranty.

END OF SECTION 233300
SECTION 233413 - AXIAL HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following:
1. Tubeaxial fans.
2. Vaneaxial fans.
4. Laboratory exhaust fan unit (LEF).

1.2 PERFORMANCE REQUIREMENTS
A. Project Altitude: Base fan performance ratings on actual Project site elevations above sea level.
B. Operating Limits: Classify according to AMCA 99.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Fan speed controllers.
B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
C. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

1.5 INFORMATIONAL SUBMITTALS
A. Field Quality Control Test Reports.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For axial fans to include in emergency, operation, and maintenance manuals.
1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with applicable performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
   1. AMCA PUBLICATION 99, "Standards Handbook".
   2. AMCA 99-0401 "Classification for Spark Resistant Construction".
   3. ANSI/AMCA Standard 204, "Balance Quality and Vibration Levels for Fans".
   4. ANSI/AMCA Standard 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating".
   5. AMCA Publication 211, "Certified Ratings Program – Product Rating Manual for Fan Air Performance".
   6. AMCA Standard 260, "Laboratory Methods of Testing Induced Flow Fans for Rating".
   7. AMCA Standard 300, "Reverberant Room Method for Sound Testing of Fans".
   8. AMCA Publication 311, "Certified Ratings Program".

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Compliance: Fans and components shall be UL listed and labeled.
   1. UL 705, "Power Ventilators."

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final locations, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.9 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

D. Coordinate electrical connection requirements with Division 26.

E. Coordinate size and location of wall openings.

1.10 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Belts: One set for each belt-driven unit.
PART 2 - PRODUCTS

2.1 TUBEAXIAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Greenheck.
   2. Loren Cook Company.
   3. Penn Barry.
   4. Twin City Fan and Blower.

B. Description: Fan wheel and housing, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.

C. Housings: Steel with flanged inlet and outlet connections.

D. Wheel Assemblies: Cast or extruded aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

E. Wheel Assemblies: Cast aluminum, machined and fitted to shaft.

F. Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   1. Service Factor: 1.5.
   2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
   3. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
   5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   8. Shaft Bearings: Radial, self-aligning ball or roller bearings.
      a. Ball-Bearing Rating Life: ABMA 9, L10 of 80,000 hours.
      b. Roller-Bearing Rating Life: ABMA 11, L10 of 80,000 hours.
      c. Extend lubrication lines to outside of casing and terminate with grease fittings.

G. Accessories:
   1. Companion Flanges: Rolled flanges of same material as housing.
   2. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
   3. Propeller Access Section Door: Short duct section bolted to fan inlet and outlet allowing access to internal fan for inspection and cleaning, of same material as housing.
   4. Mounting Clips: Horizontal ceiling or vertical mounting clips welded to fan housing, of same material as housing.
   5. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
   6. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
   7. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork, of same material as housing.
   8. Backdraft Dampers: Butterfly style, for bolting to the discharge of fan or outlet cone, of same material as housing.
   9. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to 300 deg F (149 deg C).
  10. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
11. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation of same material as housing.

12. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.

13. Inlet Cones: Round-to-round transition of same material as housing.

14. Outlet Cones: Round-to-round transition of same material as housing.

15. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.

H. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.

2. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.

I. Factory Finishes:

1. Sheet Metal Parts: Coat all components before final assembly.

2. Coatings: Epoxy, phenolic or electrostatic powder coating.
   a. Apply to finished housings.
   b. Apply to fan wheels.

2.2 VANEAXIAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck.

2. Loren Cook Company.

3. Penn Barry.

4. Twin City Fan and Blower.

B. Description: Fan wheel and housing, straightening vane section, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.

C. Housings: Steel.

1. Inlet and Outlet Connections: Flanges.

2. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.

D. Wheel Assemblies: Cast aluminum rotor with manually adjustable blade pitch airfoil-shaped blades mounted on wheel plate keyed to shaft with solid-steel key.

E. Wheel Assemblies: Cast-aluminum hub assembly, machined and fitted with threaded bearing wells to receive blade-bearing assemblies with replaceable, manually adjustable pitch cast-aluminum blades; factory mounted and balanced.

F. Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor: 1.5.

2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

3. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.


5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.

8. Shaft Bearings: Radial, self-aligning ball or roller bearings.
   a. Ball-Bearing Rating Life: ABMA 9, L10 of 80,000 hours.
   b. Roller-Bearing Rating Life: ABMA 11, L10 of 80,000 hours.
   c. Extend lubrication lines to outside of casing and terminate with grease fittings.

G. Accessories:
1. Companion Flanges: Rolled flanges of same material as housing.
2. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
3. Propeller Access Section Door: Short duct section bolted to fan inlet and outlet allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
4. Mounting Clips: Horizontal ceiling or vertical mounting clips welded to fan housing, of same material as housing.
5. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
6. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
7. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork of same material as housing.
8. Backdraft Dampers: Butterfly style, for mounting with flexible connection to the discharge of fan or direct mounted to the discharge diffuser section of same material as housing.
9. Stall Alarm Probe: Sensing probe capable of detecting fan operation in stall and signaling control devices. Control devices and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
10. Flow Measurement Port: Pressure measurement taps installed in the inlet of fan to detect and signal airflow readings to temperature-control systems. Control devices and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
11. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to 300 deg F (148 deg C).
12. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
13. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
15. Outlet Cones: Round-to-round transition of same material as housing.
16. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.

H. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
1. Enclosure Type: Totally enclosed, fan cooled.
2. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.

I. Factory Finishes:
1. Sheet Metal Parts: Coat before final assembly.
2. Coatings: Epoxy, phenolic or electrostatic powder coating.
   a. Apply to finished housings.
   b. Apply to fan wheels.
2.3 MIXED-FLOW FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Loren Cook Company.
   2. Greenheck.
   3. Trane.

B. Description: Fan wheel and housing, with integral straightening vanes, factory-mounted motor with direct or belt drive, and accessories.

C. Housings: Steel.
   1. Inlet and Outlet Connections: Outer mounting frame and companion flanges.

D. Wheel Assemblies: Steel with airfoil-shaped blades mounted on wheel plate keyed to shaft with solid-steel key.

E. Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   1. Service Factor: 1.5.
   2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
   3. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
   5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   7. Shaft Bearings: Radial, self-aligning ball or roller bearings.
      a. Ball-Bearing Rating Life: ABMA 9, L10 of 80,000 hours.
      b. Roller-Bearing Rating Life: ABMA 11, L10 of 80,000 hours.
      c. Extend lubrication lines to outside of casing and terminate with grease fittings.

F. Accessories:
   1. Mounting Clips: Horizontal ceiling or vertical mounting clips welded to fan housing, of same material as housing.
   2. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork of same material as housing.
   3. Backdraft Dampers: Butterfly style, for mounting with flexible connection to the discharge of fan or direct mounted to the discharge diffuser section of same material as housing.
   4. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
   5. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
   6. Inlet Cones: Round-to-round transition of same material as housing.
   7. Outlet Cones: Round-to-round transition of same material as housing.
   8. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.

G. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   1. Enclosure Type: Totally enclosed, fan cooled.
   2. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.

H. Factory Finishes:
   1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: Epoxy, phenolic or electrostatic powder coating.
   a. Apply to finished housings.
   b. Apply to fan wheels.

2.4 LABORATORY EXHAUST FAN UNIT (LEF)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Strobic Air.
   2. Greenheck Vektor.
   3. Twin City.

B. Description: Laboratory Exhaust Fan (LEF) unit complete with:
   1. Upblast laboratory exhaust fans.
   2. By-pass plenum.
   3. Heat recovery coils.
   4. Exhaust unit control system.

C. Upblast Laboratory Exhaust Fans:
   1. Exhaust fans shall consist of steel housing, mixed flow impellers and direct drive motor assembly.
   2. Fan impellers shall be mounted directly to the motor shaft to provide a direct drive AMCA arrangement 2 (with motor shaft to fan coupling) or arrangement 4 (no motor to fan coupling) type fan. Motors shall be isolated from the primary exhaust air stream and shall be visible and accessible from the fan exterior for inspection and service.
   3. Fan mixed flow impellers shall consist of combination axial/backward curved blades and shall be of welded steel construction. The impellers shall have non-stall and non-overloading performance characteristics with stable operation at any point on the fan curves.
   4. Stationary fan discharge guide vane sections shall be provided to increase fan efficiencies.
   5. Fan dynamic balance shall not exceed 0.5 mil, peak to peak, at the blade pass areas when operating at fan frequency.
   6. Fan assemblies shall be designed for mounting on conventional roof curb without the need for guy wire supports.
   7. Fan discharge shall include FRP or steel nozzles that are capable of generating aspiration.
   8. Fan discharge shall include fiberglass or steel entrainment windband which shall provide secondary induction of outside air. Induction shall take place downstream of the fan impeller and shall not influence BHP or static pressure requirements. Windbands shall discharge design flow rates as scheduled on the construction drawings. Fan shall be tested according to AMCA Standard 260-07.
   9. Provide non-ferrous inlet bell, AMCA C construction, to reduce sparking in the event of a motor bearing failure.
   10. Fans shall be modular construction and capable of being assembles on the roof. PTFE gaskets shall be provided at all companion flanged joints. All fasteners shall be 316 stainless steel.
   11. Bolted access door shall be provided for impeller inspection on each fan.
   12. Fans and accessories shall have internal drain systems to prevent rain water from entering building duct system.
13. Fan motors shall be TEFC Mill & Chemical duty with a 1.15 service factor and an L-10 bearing life of 200,000 hours. Maintenance shall only be required on a minimum of 18 month intervals. This maintenance shall be limited to re-greasing of the motor bearings and not require shut down of the system. All motors shall be C-Face and Foot Mounted. Motors shall be warranted by the fan manufacturer for a period of three (3) years from shipment. Extended motor lube lines of Teflon tubing covered with braided stainless steel shall be provided for each bearing. Extended lube lines shall be mounted to a bracket located on the fan housing with grease relief fittings on each line. Motors shall be inverter duty and fitted with grounding rings on the motor shaft to prevent electrical charge buildup on the shaft, causing bearing fluting.

14. NEMA 3R non-fused disconnect switch shall be provided, mounted and wired to the motor. Electrical interlocks shall be installed in each disconnect switch by the fan manufacturer.

15. Coatings: All fan steel and aluminum surfaces shall be prepared for coating by blasting or chemical etching.
   a. Coating will be Epoxy (8-10 mils) for protection against weather, chemical vapors and splashes or equal coating of zinc-rich epoxy primer coat with electrostatically applied and heat cured polyester resin powder top coating.

D. Bypass Plenum:
   1. Provide insulated, double wall bypass plenum supplied by the unit manufacturer. Plenum shall be sized to support the weight and performance requirement of the number of fans [and heat recovery coil(s)] listed on the schedule. Plenum shall be capable of supporting the fans without guy wires or supports. Plenum primary air inlets shall be located on the bottom or side as noted on construction drawings. Bottom plenum inlets shall be covered by safety screens.
   2. Plenum shall be supplied with air bypass openings to maintain minimum windband exit discharge velocity as scheduled on the construction drawings. By-pass openings shall be equipped with motorized by-pass damper and shall be shielded from rain entrainment by a weather hood.
   3. Coatings: All plenum steel and aluminum surfaces shall be prepared for coating by blasting or chemical etching. Coating will be epoxy (8-10 mils) for protection against weather, chemical vapors and splashes or equal coating of zinc-rich epoxy primer coat with electrostatically applied and heat cured polyester resin top coat.
      a. Interior liners of double wall plenum shall be stainless steel.
      b. All fasteners used shall be stainless steel. All gaskets used shall be PTFE.

E. Energy Recovery Coil:
   1. Integral with bypass plenum supply heat recovery coils and filters. Provide factory installed insulated schedule 40 welded steel piping to coils.
   2. Provide plenum access doors on both sides upstream and downstream of heat recovery coil.
   3. Coil shall be heresite coated.
   4. Locate 30 percent roughing pre filters in 304 stainless steel filter rack upstream of energy recovery coil.
   5. Provide a minimum of 18 inches on both sides upstream and downstream of heat recovery coil for coil cleaning and maintenance.
   6. Provide drain pan in accordance with ASHRAE Standard 62 where indicated on the construction drawings.
   7. Coil capacities shall be as scheduled on the construction drawings.
F. Roof Curb: Provide galvanized steel roof curb to support the fan/plenum assembly. The curb shall be minimum 12 gauge sheet metal and shall be cant for rigidity in wind loads. The curb shall be 24 inches high. The curb shall include a rigid fiberglass liner and a wood nailer.

G. Jib Crane: Provide jib crane for removal of fan for maintenance.

H. Sound Attenuators: Provide integral acoustical silencer nozzle on each fan. Silencer shall be of FRP construction. The maximum air pressure drop shall be 0.1 inch W.C. when installed and all associated losses shall be included in the fan performance curve. The acoustical silencer nozzle shall provide the attenuation to obtain sound power as scheduled on the construction drawings. The published insertion loss values shall be obtained from an AMCA 300 test with the silencer installed on the fan specified.

I. Dampers:
   1. Provide heavy duty aluminum, opposed blade, low leakage airfoil bypass damper with extended shaft and factory installed actuator on each side of the plenum for mixing outside make-up air with primary exhaust. Dampers shall have a 1/2 inch square mesh screen on the inlet side.
   2. Provide heavy duty, low leakage, extruded aluminum, opposed blade fan isolation damper with factory installed actuator at the inlet to each exhaust fan.
   3. Dampers shall have vinyl blade edge seals, stainless steel spring jamb seals, 1.5 inch x 8 inch x 1.5 inch extruded aluminum frame, jamb mounted concealed linkage and nylon bearings. Coat dampers with two coats of white epoxy or phenolic paint.
   4. Provide dampers with an extended shaft projecting through the plenum sidewall for connection to a two position, spring return electric actuator. Mount actuators and linkage in weatherproof enclosures outside the plenum. Damper shaft extensions shall be provided with a support bushing at the plenum wall.
   5. Control dampers shall be Arrow Model AFD-20, or equal by Ruskin.

J. Warranty:
   1. Equipment manufacturer shall provide a three (3) year warranty from time of purchase to include fan, motor and all drive mechanisms.

K. Laboratory Exhaust Fan Unit with Static Pressure Control Package:
   1. Provide LEF unit control package capable of maintaining the laboratory exhaust system static pressure at a predetermined level regardless of laboratory activity (i.e. opening/closing of laboratory hoods). This shall be accomplished without any user input.
   2. The outlet velocity of each fan in the exhaust system shall be maintained at a minimum of 3000 fpm at all times independent of system exhaust plenum static pressure.
   3. The static pressure at which the system is required to be maintained shall be capable of being set manually at the control package interface. The control package shall also be capable of receiving the static pressure set point from the building control system.
   4. Fans running simultaneously shall run at the same speed.
   5. The control package shall stage the fans in the system so that no one fan is idle for more than 30 days.
   6. The control package shall respond to a failure of one fan by energizing an unused fan (if present) to replace it.
   7. Provide data link communication card which will allow information to be sent from the control package to the building automation system (BAS). This information shall include the measured system static pressure, the frequency at which the VSDs are running, the power consumption of each fan and fault status.
8. Wiring shall be done in the factory so as to minimize field wiring. Control wiring shall be brought to a single point in both the rooftop LEF unit and VSD/mechanical room equipment, and shall be connected in the field with a single conduit run.
9. The controller shall be powered separately from any other component in the system.

2.5 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fans level and plumb.

B. Support floor-mounting units using vibration isolators and restraints specified in Division 23 Section "Vibration Controls for HVAC."

C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

D. Support suspended units from structure using threaded steel rods, vibration isolators, and restraints specified in Division 23 Section "Vibration Controls for HVAC."

E. Install units with clearances for service and maintenance.

F. Label fans according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."

B. Ground equipment according to Division 26 Section "Grounding and Bonding."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.

5. Adjust belt tension.

6. Adjust damper linkages for proper damper operation.

7. Verify lubrication for bearings and other moving parts.

8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

9. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.

10. Shut unit down and reconnect automatic temperature-control operators.

11. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

END OF SECTION 233413
SECTION 233416 - CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following:
   1. Airfoil centrifugal fans.
   2. Backward-inclined centrifugal fans.
   3. Forward curved centrifugal fans.
   4. Plenum fans.

1.2 PERFORMANCE REQUIREMENTS
A. Project Altitude: Base fan performance ratings on actual Project site elevations above sea level.
B. Operating Limits: Classify according to AMCA 99.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.
B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
C. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

1.5 INFORMATIONAL SUBMITTALS
A. Field Quality Control Test Reports.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.
1.7 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
   C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA 1.
   D. UL Compliance: Fans and components shall be UL listed and labeled.

1.8 DELIVERY, STORAGE, AND HANDLING
   A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.
   B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.
   C. Lift and support units with manufacturer's designated lifting or supporting points.

1.9 COORDINATION
   A. Coordinate size and location of structural-steel support members.
   B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
   C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."
   D. Coordinate electrical connection requirements with Division 26.
   E. Coordinate size and location of wall openings.

1.10 EXTRA MATERIALS
   A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      1. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Aerovent; a Twin City Fan Company.
      2. Bayley Fans; a division of Lau Industries, Inc.
      3. Greenheck Fan Corp.
      4. Loren Cook Company.
      5. Penn Barry.
      6. Twin City Fan and Blower.
2.2 AIRFOIL CENTRIFUGAL FANS

A. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor [and disconnect switch], drive assembly, and support structure.

B. Housings: Formed panels to make curved-scroll housings with shaped cutoff, with doors or panels to allow access to internal parts and components. Reinforced steel.
   1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
   2. Horizontally split, bolted-flange housing.
   3. Spun inlet cone with flange.
   4. Outlet flange.

C. Airfoil Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws. Steel wheel.

D. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
   1. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
   2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
   1. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
   2. Roller-Bearing Rating Life: ABMA 11, L10 at 120,000 hours.

   1. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
   2. Roller-Bearing Rating Life: ABMA 11, L10 at 120,000 hours.

G. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
   1. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
   2. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours.

H. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   1. Service Factor Based on Fan Motor Size: 1.5.
   2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   5. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
I. Accessories:
   1. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
   2. Cleanout Door: Quick-opening, latch-type gasketed door allowing access to fan scroll, of same material as housing.
   3. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
   4. Companion Flanges: Rolled flanges for duct connections of same material as housing.
   5. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
   6. Discharge Dampers: Assembly with opposed blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
   7. Inlet Screens: Grid screen of same material as housing.
   8. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
  10. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

J. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   1. Enclosure Type: Totally enclosed, fan cooled.

K. Characteristics: Refer to Drawings.

2.3 BACKWARD-INCLINED CENTRIFUGAL FANS

A. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.

B. Housings: Formed panels to make curved-scroll housings with shaped cutoff; with doors or panels to allow access to internal parts and components. Reinforced steel.
   1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
   2. Horizontally split, bolted-flange housing.
   3. Spun inlet cone with flange.
   4. Outlet flange.

C. Backward-Inclined Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; and fastened to shaft with set screws. Steel wheel.

D. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
   1. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
   2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
E. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
   1. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
   2. Roller-Bearing Rating Life: ABMA 11, L10 at 120,000 hours.

   1. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
   2. Roller-Bearing Rating Life: ABMA 11, L10 at 120,000 hours.

G. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
   1. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
   2. Roller-Bearing Rating Life: ABMA 11, L10 at 120,000 hours.

H. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   1. Service Factor Based on Fan Motor Size: 1.5.
   2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   5. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

I. Accessories:
   1. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
   2. Cleanout Door: Quick-opening, latch-type gasketed door allowing access to fan scroll, of same material as housing.
   3. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
   4. Companion Flanges: Rolled flanges for duct connections of same material as housing.
   5. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
   6. Discharge Dampers: Assembly with opposed blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
   7. Inlet Screens: Grid screen of same material as housing.
   8. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
   10. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

J. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   1. Enclosure Type: Totally enclosed, fan cooled.

K. Characteristics: Refer to Drawings.
2.4 FORWARD-CURVED CENTRIFUGAL FANS

A. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, disconnect switch, drive assembly, and support structure.

B. Housings: Formed panels to make curved-scroll housings with shaped cutoff; with doors or panels to allow access to internal parts and components. Reinforced steel.
   1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
   2. Horizontally split, bolted-flange housing.
   3. Spun inlet cone with flange.
   4. Outlet flange.

C. Forward-Curved Wheels: Black-enamedled or galvanized steel construction with inlet flange, backplate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.

D. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
   1. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
   2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
   1. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
   2. Roller-Bearing Rating Life: ABMA 11, L10 at 120,000 hours.

   1. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
   2. Roller-Bearing Rating Life: ABMA 11, L10 at 120,000 hours.

G. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
   1. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
   2. Roller-Bearing Rating Life: ABMA 11, L10 at 120,000 hours.

H. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   1. Service Factor Based on Fan Motor Size: 1.5.
   2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   5. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
I. Accessories:
   1. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
   2. Cleanout Door: Quick-opening, latch-type gasketed door allowing access to fan scroll, of same material as housing.
   3. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
   4. Companion Flanges: Rolled flanges for duct connections of same material as housing.
   5. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
   6. Discharge Dampers: Assembly with opposed blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
   7. Inlet Screens: Grid screen of same material as housing.
   8. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
  10. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

J. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   1. Enclosure Type: Totally enclosed, fan cooled.

K. Characteristics: Refer to Drawings.

2.5 PLENUM FANS
   A. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven or direct-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor [and disconnect switch], drive assembly, and support structure.
   B. Airfoil Wheels: Single-width-single-inlet construction with smooth-curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws. Steel wheel.
   C. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
      1. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
      2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
      1. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
      2. Roller-Bearing Rating Life: ABMA 11, L10 at 120,000 hours.
   E. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
      1. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, L10 at 120,000 hours.

F. Fan Drive: Belt-drive or direct-drive. Refer to Drawings.
   1. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
      a. Service Factor Based on Fan Motor Size: [1.5] [1.4] [1.3] [1.2].
      b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
      d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
      e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
      f. Motor Mount: Adjustable for belt tensioning

G. Accessories:
   1. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.

H. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   1. Enclosure Type: Totally enclosed, fan cooled.

I. Characteristics: Refer to Drawings.

2.6 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Support floor-mounting units using vibration isolators and restraints specified in Division 23 Section "Vibration Controls for HVAC."
   1. Secure vibration and restraint controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."
D. Support suspended units from structure using threaded steel rods, vibration isolators, and restraints, specified in Division 23 Section "Vibration Controls for HVAC."

E. Install units with clearances for service and maintenance.

F. Label fans according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install line-sized piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain.

D. Ground equipment according to Division 26 Section "Grounding and Bonding."

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
10. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 DEMONSTRATION

A. Train Owner’s maintenance personnel to adjust, operate, and maintain centrifugal fans. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 233416
SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Utility set fans.
   2. Centrifugal roof ventilators.
   3. In-line centrifugal fans.
   4. Propeller fans.

1.2 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.
B. Operating Limits: Classify according to AMCA 99.
C. Seismic and Wind Performance: Withstand the effects of seismic and wind forces determined by Division 23 Section "Vibration Controls for HVAC."

1.3 SUBMITTALS

A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.
   7. Roof curbs.
   8. Fan speed controllers.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Roof framing and support members relative to duct penetrations.
   2. Ceiling suspension assembly members.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
1.5 INFORMATIONAL SUBMITTALS
   A. Field Quality Control Test Reports.

1.6 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
   C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
   D. UL Standard: Power ventilators shall comply with UL 705.
   E. UL Compliance: Fans and components shall be UL listed and labeled.

1.8 DELIVERY, STORAGE, AND HANDLING
   A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
   B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
   C. Lift and support units with manufacturer's designated lifting or supporting points.
   D. Coordinate electrical connection requirements with Division 26.
   E. Coordinate size and location of wall openings.

1.9 COORDINATION
   A. Coordinate size and location of structural-steel support members.
   B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
   C. Coordinate installation of roof curbs, equipment supports, equipment restraints, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories" and Division 23 Section "Vibration Controls for HVAC."

1.10 EXTRA MATERIALS
   A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      1. Belts: One set for each belt-driven unit.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Aerovent; a Twin City Fan Company.
2. Bayley Fans; a division of Lau Industries, Inc.
3. Greenheck Fan Corp.
4. Loren Cook Company.
5. Penn Ventilation.
6. Penn Barry.
7. Trane.
8. Twin City Fan and Blower.

2.2 UTILITY SET FANS

A. Description: Centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.

B. Drive:

1. Direct drive for units with motors 15 HP and less.
2. Belt-drive for unit with motors over 15 HP.

C. Housing: Fabricated of steel with side sheets fastened with a deep lock seam or welded to scroll sheets.

1. Housing Discharge Arrangement: Adjustable to eight standard positions.

D. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.

1. Blade Materials: Steel or Aluminum.
2. Blade Type: Backward inclined or Airfoil.
3. Spark-Resistant Construction: AMCA 99, Type [A] [B] [C].

E. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

F. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L₁₀ of 100,000 hours.

G. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.5.
3. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.

H. Accessories:

1. Inlet and Outlet: Flanged.
2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Access Door: Gasketed door in scroll with latch-type handles.
5. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
6. Inlet Screens: Removable wire mesh.
9. Discharge Dampers: Assembly with opposed blades constructed of two plates formed around and to shaft, channel frame, sealed ball bearings, with blades linked outside of airstream to single control lever of same material as housing.
10. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
11. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

I. Spark Arrestance Class: [A] [B] [C].

2.3 CENTRIFUGAL ROOF VENTILATORS
A. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
B. Drive:
1. Direct drive for units with motors 7-1/2 HP and less.
2. Belt-drive for unit with motors over 7-1/2 HP.
C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
4. Fan and motor isolated from exhaust airstream.
F. Accessories:
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfuseable type, NEMA 3R or greater, as required by application and environment of the fan, with thermal-overload protection mounted [inside] [outside] fan housing, factory wired through an internal aluminum conduit. All service disconnect switches shall have a means of being locked to provide a degree of safety when the fan is being serviced. Type NEMA 1 service disconnect switches will not be allowed.
3. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
G. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.
   1. Configuration: To match roofing details and system.
   2. Overall Height: 16 inches (400 mm).

2.4 IN-LINE CENTRIFUGAL FANS
A. Description: In-line, centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
B. Drive:
   1. Direct drive for units with motors 7-1/2 HP and less.
   2. Belt-drive for unit with motors over 7-1/2 HP.
C. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
D. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.
E. Belt-Driven Units: Motor mounted on adjustable base, with fixed-pitch sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
F. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
G. Accessories:
   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
   3. Companion Flanges: For inlet and outlet duct connections.
      Provide guard for inlet or outlet for units not connected to ductwork.
   5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
   6. Spark Arrestance Class: [A] [B] [C].

2.5 PROPELLER FANS
A. Description: Direct- or belt-driven propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.
B. Drive:
   1. Direct drive for units with motors 7-1/2 HP and less.
   2. Belt-drive for unit with motors over 7-1/2 HP.
C. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.
D. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.
E. Fan Wheel: Replaceable, cast-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

F. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.4.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   a. Ball-Bearing Rating Life: ABMA 9, L₁₀ of 100,000 hours.
4. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
6. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.

G. Accessories:

1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
3. Wall Sleeve: Galvanized steel to match fan and accessory size.
4. Weathershield Hood: Galvanized steel to match fan and accessory size.
5. Weathershield Front Guard: Galvanized steel with expanded metal screen.
6. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
7. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
8. Spark Arrestance Class: [A] [B] [C].

2.6 MOTORS

A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

B. Enclosure Type: Totally enclosed, fan cooled.

2.7 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.
B. Support units using vibration isolators and restraints specified in Division 23 Section "Vibration Controls for HVAC."
   1. Secure vibration and restraint controls to concrete bases using anchor bolts cast in concrete base.
C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."
D. Secure roof-mounting fans to roof curbs with cadmium-plated hardware, and attach roof curbs to structure. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.
E. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
F. Support suspended units from structure using threaded steel rods, vibration isolators, and restraints specified in Division 23 Section "Vibration Controls for HVAC."
G. Install units with clearances for service and maintenance.
H. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS
A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."
B. Install ducts adjacent to power ventilators to allow service and maintenance.
C. Ground equipment according to Division 26 Section "Grounding and Bonding."
D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL
A. Perform the following field tests and inspections and prepare test reports:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   5. Adjust belt tension.
   6. Adjust damper linkages for proper damper operation.
   7. Verify lubrication for bearings and other moving parts.
   8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
   9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
  10. Shut unit down and reconnect automatic temperature-control operators.
  11. Remove and replace malfunctioning units and retest as specified above.
B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.
B. Adjust belt tension.
C. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
D. Replace fan and motor pulleys to achieve design airflow.
E. Lubricate bearings.

END OF SECTION 233423
SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY
A. Section Includes:
   1. Fan-powered air terminal units.
   2. Single-duct air terminal units.

1.2 SUBMITTALS
A. General: Submit the following in accordance with Conditions of Contract, Division 01 Specification Sections and Division 23 Section "Basic Division 23 Requirements".

1.3 ACTION SUBMITTALS
A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.
   1. All air terminal unit components.
   2. Liners and adhesives.
B. Shop Drawings: Plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS
A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS
A. Maintenance data for air terminal units for inclusion in Operating and Maintenance Manual specified in Division 01 and Division 23 Section "Basic Mechanical Requirements".

1.6 QUALITY ASSURANCE
A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
B. FGI / ASHRAE 170 Compliance: Airstream surfaces shall comply with requirements of FGI and ASHRAE 170, Section 6 requirements.
C. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
D. NFPA Compliance: Install air terminal units according to the current edition of NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

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PART 2 - PRODUCTS

2.1 FAN-POWERED AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Krueger.
   2. Nailor Industries of Texas, Inc.
   4. Titus.
   5. Johnson Controls, Inc - JCI

B. Configuration: Volume-damper assembly and fan in parallel or series arrangement inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.034-inch (0.85-mm) steel.
   1. Casing Lining: Adhesive attached, 1-inch- (25-mm-) thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
      a. Cover liner with solid sheet metal.
   2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
   3. Air Outlet: S-slip and drive connections.
   4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
   5. Fan: Forward-curved centrifugal.
   6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Access: Provide 8 inch x 8 inch hinged access door in bottom of casings to permit access to air dampers and upstream side of coil and other parts requiring service, adjustment or maintenance. Provide with airtight gasket and quarter turn latches.

E. Leakage: Construct casings such that when subjected to 0.5 inch w.g. pressure for low pressure units, and 3-inch w.g. pressure for high pressure units, total leakage does not exceed 4 percent of specified air flow capacity with outlets sealed and inlets wide open. Construct air dampers such that when subjected to 6.0 inch w.g. inlet pressure with damper closed, total leakage does not exceed 10 percent of specified air flow capacity.

F. Air Dampers: Construct of materials that cannot corrode, do not require lubrication, nor require periodic servicing. Provide maximum volume dampers, both pressure dependent and pressure compensated, that are calibrated in cfm, factory-adjusted, and marked for specified air capacities. Provide mechanism to vary air volume through damper for minimum to maximum, in response from signal from room temperature sensor.

G. Flow Sensor: The unit inlet shall be equipped with a cross-shaped or full perimeter flow sensor with amplifying pressure pickup points connected to central averaging chambers. The sensor shall amplify the duct velocity pressure by a factor of 1.75 and shall maintain control accuracy with the same size inlet duct in any configuration. The flow sensor shall ensure accurate air delivery within +/- 5 percent of the factory set air volume under all conditions, independent of system static pressure.
H. Volume Control: The terminal unit manufacturer shall provide the unit casing, damper, shaft, insulation, pressure sensing tubes, and reheat coil. The controls manufacturer shall provide the direct digital controller (including the damper motor) for control to mount directly on the unit. The terminal unit manufacturer shall mount the controller on the unit to provide a complete factory assembled unto the field.

I. Identification: Provide label on each unit indicating Plan Number, cfm range, cfm factory setting and calibration curve (if required).

J. Motor:
1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
2. Type: Electronically commutated motor.
4. Motor Speed Control: Infinitely adjustable with output signal from BAS.
5. Electrical Characteristics: See schedule on Drawings.

K. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
1. Material: Pleated cotton-polyester media having 90 percent arrestance and 7 MERV.
2. Thickness: 2 inches (50 mm).

L. Hydronic Coils: Construct of 1/2“ OD, 0.016 inch thick, seamless copper tubes, with mechanically bonded 0.0045 inch thick plate aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve. Leak test at 300 psig under water.
1. All coils shall be a minimum of two (2) rows, regardless of scheduled capacity or leaving air temperature.

M. Factory-Mounted Inlet Sound Attenuator: Minimum 0.028” (22 GA) galvanized steel housing, mechanically sealed, leak-resistant construction. Provide adhesive-attached 1” thick, 1.5 PCF internal insulation attached to housing. Insulation shall meet requirements of NFPA 90A and UL181. Attenuation properties shall be as scheduled on the drawings.

N. Factory-Mounted and -Wired Controls: Electrical components mounted in control box. A cover is not required. Incorporate single-point electrical connection to power source.
1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
3. Disconnect Switch: Factory-mounted, fuse type.

O. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

2.2 SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Krueger.
2. Nailor Industries of Texas, Inc.
4. Titus.
5. Johnson Controls, Inc - JCI

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.034-inch (0.85-mm) steel.
   1. Casing Lining: Adhesive attached, [1-inch- (25-mm-)] thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
      a. Cover liner with solid sheet metal.
   2. Air Inlet: Round stub connection for duct attachment.
   3. Air Outlet: S-slip and drive connections.
   4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Access: Provide 8 inch x 8 inch hinged access door in bottom of casings to permit access to air dampers and upstream side of coil and other parts requiring service, adjustment or maintenance. Provide with airtight gasket and quarter turn latches.

E. Leakage: Construct casings such that when subjected to 0.5 inch w.g. pressure for low pressure units, and 3-inch w.g. pressure for high pressure units, total leakage does not exceed 4 percent of specified air flow capacity with outlets sealed and inlets wide open. Construct air dampers such that when subjected to 6.0 inch w.g. inlet pressure with damper closed, total leakage does not exceed 10 percent of specified air flow capacity.

F. Air Dampers: Construct of materials that cannot corrode, do not require lubrication, nor require periodic servicing. Provide maximum volume dampers, both pressure dependent and pressure compensated, that are calibrated in cfm, factory-adjusted, and marked for specified air capacities. Provide mechanism to vary air volume through damper for minimum to maximum, in response from signal from room temperature sensor.

G. Flow Sensor: The unit inlet shall be equipped with a cross-shaped or full perimeter flow sensor with amplifying pressure pickup points connected to central averaging chambers. The sensor shall amplify the duct velocity pressure by a factor of 1.75 and shall maintain control accuracy with the same size inlet duct in any configuration. The flow sensor shall ensure accurate air delivery within +/- 5 percent of the factory set air volume under all conditions, independent of system static pressure.

H. Volume Control: The terminal unit manufacturer shall provide the unit casing, damper, shaft, insulation, pressure sensing tubes, and reheat coil. The controls manufacturer shall provide the direct digital controller (including the damper motor) for control to mount directly on the unit. The terminal unit manufacturer shall mount the controller on the unit to provide a complete factory assembled unto the field.

I. Identification: Provide label on each unit indicating Plan Number, cfm range, cfm factory setting and calibration curve (if required).
J. Hydronic Coils: Construct of 1/2 inch OD, 0.016 inch thick, seamless copper tubes, with 0.0045 inch thick plate mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve. Leak test at 300 psig under water.
   1. All coils shall be a minimum of two (2) rows, regardless of scheduled capacity or leaving air temperature.

K. Factory-Mounted and -Wired Controls: Electrical components mounted in control box. A cover is not required. Incorporate single-point electrical connection to power source.
   1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
   2. Wiring Terminations: Controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
   3. Disconnect Switch: Factory-mounted, fuse type.

L. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

2.3 HANGERS AND SUPPORTS
   A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
   B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
   C. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
   D. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.4 SOURCE QUALITY CONTROL
   A. Factory Tests: Test assembled air terminal units according to ARI 880.
      1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
   B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

3.2 HANGER AND SUPPORT INSTALLATION
   A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
   B. Install per Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

AIR TERMINAL UNITS

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C. Hangers Exposed to View: Threaded rod and angle or channel supports.
D. Provide vibration isolation hangers and supports for fan-powered terminal units with minimum 1-inch deflection.

3.3 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.
B. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping" connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
C. Connect medium-pressure ducts to terminal units using hard duct connections. Flexible ducts will not be accepted.
D. Connect the low-pressure supply connection to fan-powered terminal units with flexible connectors complying with requirements in Division 23 Section "Air Duct Accessories."

3.4 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
   2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
B. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
   3. Verify that controls and control enclosure are accessible.
   4. Verify that control connections are complete.
   5. Verify that nameplate and identification tag are visible.
   6. Verify that controls respond to inputs as specified.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600
SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

1.2 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS
A. Product Data: For each product indicated, include the following:
   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   5. Duct access panels.

C. Color Samples: For diffusers, registers, and grilles with factory-applied color finishes.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Unless otherwise indicated, subject to compliance with requirements, provide products by one of the following:
   1. Diffusers, Grilles, Registers:
      a. Nailor.
      b. Price.
      c. Titus Product Co.

2.2 AIR DEVICES
A. General: Except as otherwise indicated, provide manufacturer's standard air devices where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide air supply devices that have, as minimum, temperature and velocity traverses, throw and drop, pressure drop and noise criteria ratings for each size device as listed in manufacturer's current data. Provide air return devices that have, as a minimum, pressure drop and noise criteria ratings for each size device as listed in manufacturer's current data.
C. Ceiling Compatibility: Provide air devices with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Provide drop face type air devices where drop face ceiling tile is indicated. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air devices.

D. Wall Compatibility: Provide air devices with border styles that are compatible with adjacent wall systems, and that are specifically manufactured to fit into wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for type of wall air device.

2.3 CEILING SUPPLY AIR DIFFUSERS (TYPE 1, 2, 3, 4)
   A. Style: Plaque face square or rectangular, discharge in one through four directions, directional tabs in back cone, equal to Price Model SPD.
   B. Material: Steel or aluminum.
   C. Size: Sizes shown on Drawing are first number CFM, second number throw/type (1, 2, 3, or 4 way). Lay-in units to be full size of tile.
   D. Finish: Baked powder electrostatically applied finish; custom color as selected by Architect.

2.4 CEILING RETURN AND EXHAUST AIR REGISTERS (TYPE 5)
   A. Style: Louvered face square or rectangular, removable inner assembly, 45 deg. deflection, 3/4 inch blade spacing, equal to Price Model SPD, 530D or 630D with NT frame.
   B. Face style to match supply diffuser in same room.
   C. Material: Steel or aluminum.
   D. Accessories: Key operated opposed blade volume damper.
   E. Size: Sizes shown on Drawing are first number is CFM, second number type. Lay-in units to be full size of tile.
   F. Finish: Baked powder electrostatically applied finish; custom color as selected by Architect.

2.5 LINEAR CEILING SUPPLY AIR DEVICE (TYPE 7)
   A. Style: Straight line linear supply air slot diffuser, flush type, with mounting brackets, removable pattern volume control vanes, equal to Price Model SDS.
   B. Material: Extruded aluminum.
   C. Size: Number of slots and slot width as shown on Drawings.
   D. Finish: Anodized or powder electrostatically applied finish; custom color as selected by Architect.
   E. Frame: Coordinate with ceiling construction.

2.6 LINEAR CEILING RETURN/EXHAUST AIR DEVICES (TYPE 7R)
   A. Style: Straight line, linear return air slot diffuser, flush type with mounting brackets, equal to Price Model SDR.
   B. Material: Extruded aluminum.
   C. Size: Number of slots and slot width as shown on Drawings.
D. Finish: Anodized or baked powder electrostatically applied finish; custom color as selected by Architect.

E. Frame: Coordinate with ceiling construction.

2.7 LINEAR CEILING SUPPLY AIR DEVICE (TYPE 8)
A. Style: Straight or curved line, adjustable, single or double slot ceiling supply air diffuser, with mounting brackets, pattern control elements. Adjustable slot diffuser, equal to Price Model AS Series.

B. Material: Extruded aluminum.

C. Size: Number of slots and slot width as shown on Drawings.

D. Finish: Anodized or powder electrostatically applied finish; custom color as selected by Architect.

E. Frame: Coordinate with ceiling construction.

2.8 LINEAR RETURN/EXHAUST AIR DEVICE (TYPE 8R)
A. Style: Straight or curved line, single or double slot ceiling return air diffuser, with mounting brackets, equal to Price Model AS.

B. Material: Extruded aluminum.

C. Size: Number of slots and slot width as shown on Drawings.

D. Finish: Anodized or baked powder electrostatically applied finish; custom color as selected by Architect.

E. Frame: Coordinate with ceiling construction.

2.9 LINEAR SIDEWALL SUPPLY AIR DEVICE (TYPE 9A)
A. Style: Straight line, adjustable, single or double slot sidewall supply air jet-slot diffuser, with mounting brackets, pattern control elements, equal to Price Model JS.

B. Material: Extruded aluminum.

C. Size: Number of slots and slot width as shown on Drawings.

D. Finish: Anodized or powder electrostatically applied finish; custom color as selected by Architect.

E. Frame: Coordinate with wall construction.

2.10 LINEAR SIDEWALL SUPPLY AIR DEVICE (TYPE 9B)
A. Type: Bar type linear sidewall supply air diffuser, removable core, zero degree deflecting bar, 1/8 inch thick, 1/4 inch on center, with directional vanes, equal to Price Model LBPH-15A.

B. Material: Extruded aluminum.

C. Size: Sizes indicated are nominal face area.

D. Accessories: Key operated opposed blade vertical volume damper.

E. Finish: Anodized or baked powder electrostatically applied finish; custom color as selected by Architect.
2.11 LINEAR RETURN/EXHAUST AIR DEVICE (TYPE 9BR)

A. Type: Bar type fixed linear return/exhaust register, removable core, zero degree deflecting bar, 1/8 inch thick, 1/4 inch on center, equal to Price Model LBPH-15A.

B. Material: Extruded aluminum.

C. Size: Sizes indicated are nominal face area.

D. Accessories: Key operated opposed blade vertical volume damper.

E. Finish: Anodized or baked powder electrostatically applied finish; custom color as selected by Architect.

2.12 LAMINAR AIR FLOW CEILING SUPPLY AIR DISTRIBUTION SYSTEM (TYPE 10)

A. Manufacturers: Unless otherwise indicated, subject to compliance with requirements, provide products by one of the following:

1. Precision Air Product Co-Lamivent/Hepavent System.

B. Laminar Air Flow Supply Air Diffusers:

1. Provide perforated panel laminar air flow supply air diffusers complete with air equalizing plate or inlet diffusion basket. Diffuser shall deliver air to the space with zero aspiration at the face of the perforated plate. Velocities in the plane of the perforated plate shall vary no more than 10 percent.

2. Perforated distribution plate to be .040 inch thick aluminum. Perforations to be 16 percent free area for 40 or less CFM per square ft. of module or 23 percent free area for 45 to 65 CFM per square ft. of module. Plate shall be retained to the module frame through the use of captive stainless steel quarter-turn fasteners. Safety retainers of vinyl-coated stainless steel cable or chain shall be provided to prevent accidental dropping of plate.

3. Diffuser shall be supplied with a 0.040 inch thick aluminum plenum box. All internal plenum corners and seams shall be spot welded and fully sealed. Plenum box shall be externally factory insulated with 1-1/2 inch thick FSK faced 1#/cf density fiberglass insulation.

C. Fill-In Panels: Provide aluminum panels in locations as shown on the plans.

D. HEPA Filter Option: Provide perforated panel laminar airflow supply diffuser complete with a HEPA grade filter provided by the manufacturer. HEPA filter shall be accessible and removable from the room. Supply "knife edge" retainer frame which with the filter's liquid gel shall form an airtight seal. Filter shall be mounted with stainless steel retaining clips on the downstream side of the filter frame. The HEPA filter shall be laminar flow grade and have a minimum efficiency of 99.99 percent on particles 0.3 micron or larger. Each filter shall be factory laser scanned and certified by the filter manufacturer. The extruded aluminum filter frame shall be 3 inch deep and shall be furnished with a dielectric, silicon gel seal in the upstream cup flange. The filter shall be permanently bonded to the frame with a fire retardant urethane sealant.

1. Each back of HEPA filters shall be equipped with an analog DDC static pressure sensor tied to the building BAS for remote monitoring.

2. Provide ceiling diffuser which can accept a standard size filter within the frame of the filter bank.

2.13 LAMINAR AIR FLOW CEILING SUPPLY AIR DIFFUSER (TYPE 11A)

A. Manufacturers: Unless otherwise indicated, subject to compliance with requirements, provide products by one of the following:
1. Price – Model LFDC.
2. Precision Air Products Co. – Model SPD.

B. Construction:
   1. Provide perforated panel laminar air flow supply air diffusers complete with air equalizing plate or inlet diffusion basket. Diffuser shall deliver air to the space with zero aspiration at the face of the perforated plate. Velocities in the plane of the perforated plate shall vary no more than 10 percent.
   2. Perforated distribution plate to be 0.040 inch thick aluminum. Perforations to be 16 percent free area for 40 or less CFM per square ft. of module or 23 percent free area for 45 to 65 CFM per square ft of module. Plate shall be retained to the module frame through the use of captive stainless steel quarter-turn fasteners. Safety retainers of vinyl-coated stainless steel cable or chain shall be provided to prevent accidental dropping of plate.
   3. Diffuser shall be supplied with a 0.040 inch thick aluminum plenum box. All internal plenum corners and seams shall be spot welded and fully sealed. Plenum box shall be externally factory insulated with 1-1/2 inch thick FSK faced 1#/cf density fiberglass insulation.
   4. Provide balancing damper which shall be adjustable by turning a screw from the room side of the diffuser.

2.14 LAMINAR FLOW CLEAN ROOM SUPPLY AIR DIFFUSER (TYPE 11B)

A. Manufacturers: Unless otherwise indicated, subject to compliance with requirements, provide products by one of the following:
   1. Precision Air Product Co. – Model SPD.
   2. Price – Model LFDC.

B. Construction:
   1. Provide perforated panel laminar supply air flow supply diffuser complete with air diffusion plate or inlet diffusion basket. Diffuser shall be supplied with a 2 inch thick HEPA grade filter. HEPA filter shall be accessible and removable from the room. Supply "knife edge" retainer frame which with the filter's liquid get shall form an airtight seal. Filter shall be mounted with stainless steel retaining clips on the downstream side of the filter frame. Diffuser shall deliver air to the space with zero aspiration at the face of the perforated plate and velocities in the plane of the perforated plate shall vary no more than 10 percent. The filter housing and the inlet shall be constructed of 0.040 inch thick aluminum. All internal plenum corners and seams shall be spot welded and sealed to insure an airtight housing. The housing shall be sized to fit into a suspended T-Bar clean room ceiling system.
   2. Supply remote balancing damper mechanism which shall be adjustable by turning a screw from the room side of the diffuser.
   3. Equip housing with a static pressure port to measure resistance across the filter and to sample a test aerosol concentration on the upstream side of the filter when testing.
   4. Plenum box shall be factory insulated with 1-1/2 inch thick, FSK faced, 1#/cf density fiberglass.

C. Filters:
   1. The HEPA filter shall be 2 inch thick laminar flow grade and have a minimum efficiency of 99.9995 percent on particles 0.12 micron or larger. Each filter shall be factory laser scanned and certified by the filter manufacturer. Each filter shall comply with the specification IES-RP-CC-001.3 as a Type F filter.
   2. Provide ceiling diffuser which can accept a standard size filter within the frame of the filter bank.
2.15 FLUSH FACE RADIAL FLOW SUPPLY AIR DIFFUSER (TYPE 11C)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Price - Model AFRFDC.
   2. Titus – Model R
   3. Approved equal.

B. General:
   1. Provide radial flow supply diffuser with internal directional vanes, perforated face plate, integral 2 inch thick HEPA filter and plenum box.

C. Construction:
   1. Face plate and plenum box shall be constructed of 0.040 inch thick aluminum. All internal plenum box corners, joints and seams shall be spot welded and fully sealed. Plate shall be retained to the module frame through the use of quarter-turn fasteners. Safety retainers of vinyl-coated stainless steel cable or chain shall be provided to prevent accidental dropping of plate. Distribution plate shall be installed and in extruded aluminum mounting frame with mitered back-welded corners.
   2. Supply remote balancing damper mechanism which shall be adjustable by turning a screw from the room side of the diffuser.
   3. Plenum box shall be factory insulated with 1-1/2 inch thick, FSK faced, 1#/cf, fiberglass insulation.
   4. Filters: The HEPA filter shall be 2 inch thick laminar flow grade and have a minimum efficiency of 99.9995 percent on particles 0.12 micron or larger. Each filter shall be factory laser scanned and certified by the filter manufacturer. Each filter shall comply with the specification IES-RP-CC-001.3 as a Type F filter.

D. Size: Sizes and inlet size shall be as indicated on the Drawings.

E. Finish: Provide B11 sterile white thermal setting.

F. Accessories: Provide with air equalizing plate or inlet basket if unit is supplied without HEPA filter.

2.16 DROP FACE RADIAL FLOW SUPPLY AIR DIFFUSER (TYPE 11D)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Price - Model RFD.
   2. Titus – Model RadiaTec
   3. Approved equal.

B. General:
   1. Provide radial flow supply diffuser with hinged, perforated face plate, extending approximately 6 inches below ceiling, integral 2 inch thick HEPA filter and plenum box.

C. Construction:
   1. Face plate and plenum box shall be constructed of 0.040 inch thick aluminum. All internal plenum box corners, joints and seams shall be spot welded and fully sealed. Hinged face plate shall be retained to the module frame through the use of quarter-turn fasteners. Distribution plate shall be installed and in extruded aluminum mounting frame with mitered back-welded corners.
2. Supply remote balancing damper mechanism which shall be adjustable by turning a screw from the room side of the diffuser.
3. Plenum box shall be factory insulated with 1-1/2 inch thick, FSK faced, 1#/cf, fiberglass insulation.
4. Filters: The HEPA filter shall be 2 inch thick laminar flow grade and have a minimum efficiency of 99.9995 percent on particles 0.12 micron or larger. Each filter shall be factory laser scanned and certified by the filter manufacturer. Each filter shall comply with the specification IES-RP-CC-001.3 as a Type F filter.

D. Size: Sizes and inlet size shall be as indicated on the Drawings.
E. Finish: Provide B11 sterile white thermal setting.
F. Accessories: Provide with air equalizing plate or inlet basket if unit is supplied without HEPA filter.

2.17 SIDEWALL SUPPLY AIR REGISTERS (TYPE 14A)
A. Double deflection, 3/4 inch louver spacing, front set of horizontal individually adjustable louvers, for throw control, second set of individually adjustable vertical louvers for spread control, equal to Price Model 520-D or 620-D.
B. Material: Steel or aluminum.
C. Size: Sizes shown on Drawings are nominal face of register.
D. Accessories: Key operated opposed blade vertical volume damper, plaster frame.
E. Finish: Prime white or baked powder electrostatically applied finish; color as selected by Architect.

2.18 SIDEWALL SUPPLY AIR REGISTERS (TYPE 14B)
A. Type: Double deflection, removable and reversible core for 5 or 15 degrees upward or downward bar deflection, second set of individually adjustable vertical louvers for spread control, equal to Price Model LBMRD with DV-1 directional vanes.
B. Material: Extruded aluminum.
C. Size: Sizes shown on Drawings are nominal face of register.
D. Accessories: Key operated opposed blade vertical volume damper.
E. Finish: Prime white or baked powder electrostatically applied finish; color as selected by Architect.

2.19 RETURN/EXHAUST AIR REGISTERS (TYPE 15: CEILING REGISTER, TYPE 16: SIDEWALL REGISTER AT HIGH LEVEL, TYPE 17: SIDEWALL REGISTER AT LOW LEVEL)
A. Style: Single deflection, 3/4 inch louver spacing, equal to Price Model 530D or 630D Series.
B. Style: Single deflection, removable and reversible core for 5 or 15 degrees upward or downward bar deflection, equal to Price Model LBMRD.
C. Material: Extruded aluminum.
D. Size: Sizes shown on Drawings are nominal face of register.
E. Visually compatible with supply air registers.
F. Accessories: Key operated opposed blade vertical volume damper (registers only).
G. Finish: No. 4 prime coat or natural aluminum for sidewall, baked powder for ceilings; color as selected by Architect.

2.20 HEAVY DUTY RETURN REGISTERS (TYPE 16 HD, 17 HD)
A. Type: Wall mounted, equal to Price Model 90D Series.
B. Material: Core 14 ga. steel, heavy gauge 1-1/4 inch flat steel border.
C. Construction: 45 degree deflection fixed louver type, with blades spaced 3/8 inch on center, 14 ga. steel blades and heavy duty support bars and frame. Blades shall run parallel to the long dimension of the register.
D. Damper: Shall be flat black finish and be operable from register face.
E. Finish: Baked powder electrostatically applied finish; color as selected by Architect.

2.21 SILL SUPPLY AIR REGISTERS (TYPE 18)
A. Type: Aluminum linear fixed diffuser; deflecting bar 15 degree, 1/8 inch thick, 1/4 inch on center; second set of louvers for spread control, spring retaining clips, equal to Price model LBP-16A with directional vanes.
B. Material: Extruded aluminum.
C. Size: Sizes indicated are nominal face area.
D. Accessories: Key operated opposed blade vertical volume damper.
E. Finish: Anodized or baked powder electrostatically applied finish; color as selected by Architect.

2.22 FAN COIL UNIT DISCHARGE AIR GRILLES (TYPE 19)
A. Type: Aluminum linear fixed diffuser; deflecting bar 15 degree, 1/8 inch thick, 1/4 inch on center; second set of louvers for spread control; spring retaining clips, equal to Price Model LBP-16A with DV directional vanes.
B. Material: Extruded aluminum.
C. Access Doors: Access doors shall be at the left or right and of grilles as shown on the Drawings.
D. Size: Sizes indicated are nominal face area.
E. Finish: Anodized; color as selected by Architect.

2.23 HEPA FAN FILTER UNIT
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. HEPA Fan Filter Unit:
      a. Enviroco, MAC 10 Series.
      b. Price FFU.
   B. General: Provide factory-fabricated and tested HEPA modules as indicated, selected with performance characteristics which match or exceed those indicated on the Drawings.
   C. Construction:
      1. Aluminum filter plenum with integral blower housing.
      2. Threaded nuts in each corner for seismic hanger loops.
3. Replaceable filter module.
4. HEPA filter, factory sealed in an extruded aluminum frame for leak free operation.
5. Room side access for filter replacement.
6. Gasketed face.

D. Filter Media - Replaceable: Aluminum frames High Efficiency Particulate Air (HEPA) filter with a minimum efficiency of 99.99 percent at 0.3 micron, aerosol challenged (RP-1 type).

E. Prefilter: Not used on ducted unit.

F. Airflow: 90 feet per minute ± 10 FPM average velocity, 6 inches from diffuser screen.

G. Motor/Blower Assembly: Direct drive, continuous duty motor with inherent overload protection. Assembly is designed to provide rated airflow through an increase from .425 inches to .85 inches w.g.

H. Electrical Standard: 115 volt, single phase, 60 Hz, wired to junction box, with variable two speed switch.

I. Maximum sound power level at high fan speed shall not exceed 48 db in band 5 and 6 at 30 inches from unit nor exceed 40 N.C.

J. Accessories: 10 inch diameter duct collar.

K. Warranty:
   1. One year on mechanical parts and labor.
   2. Two year unlimited warranted on filter loading.

2.24 PLENUMS FOR LINEAR CEILING AND SIDEWALL SUPPLY/RETURN/EXHAUST DEVICES

A. Install diffuser with shop fabricated plenum as detailed on the Drawings.

B. Install diffusers with factory fabricated plenums. Plenums shall be fabricated of 22 gauge minimum G-90 galvanized sheet metal. Provide with 1/2 inch thick internal sound lining. Plenum height shall accommodate round supply duct connections of size indicated on the Drawings. Plenum shall be equal to Price Model UP.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Install diffusers, registers, and grilles with restraints designed to withstand, without damage to equipment, seismic forces required by Division 23 Section "Vibration Controls for HVAC."

DIFFUSERS, REGISTERS, AND GRILLES 233713 - 9
C. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

D. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

E. Paint ductwork or plenums behind diffusers, registers and grilles flat black for a distance sufficient to cover exposed sheetmetal.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713
SECTION 234100 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications.

1.2 DEFINITIONS
   A. DOP: Dioctyl phthalate or bis-(2-ethylhexyl) phthalate.
   B. HEPA: High-efficiency particulate air.
   C. ULPA: Ultra low penetration air.

1.3 SUBMITTALS
   A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS
   A. Product Data: Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
   B. Shop Drawings:
      1. Layout Drawings: Include plans, elevations, sections, and details to illustrate component assemblies and attachments.
      2. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
      3. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

1.5 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE
   A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air filters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
   B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   C. Comply with the current edition of ASHRAE 52.2 for method of testing and rating air-filter units.
   D. Comply with NFPA 70 for installing electrical components.
   E. Comply with the current edition of NFPA 90A.
1.7 COORDINATION
   A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8 EXTRA MATERIALS
   A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      1. Provide one complete set of filters for each filter bank. If system includes prefilters, provide only prefilters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Air Filters, Electrostatic Air Cleaners, and Filter-Holding Systems:
         a. AAF International.
         b. Aerostar
         c. Airguard Industries, Inc.
         d. Camfil Farr Co.
         e. Flanders Filters, Inc.
      2. Filter Gages:
         a. Airguard Industries, Inc.
         b. Dwyer Instruments, Inc.

2.2 AIR FILTERS
   A. Disposable Pleated Panel Filter, UL Class 2: Air filters shall be medium efficiency, pleated, disposable type. Each filter shall consist of a cotton and synthetic media, media support grid, and enclosing frame. The filter shall be listed and identified on the frame as Underwriters' Laboratories Class 2. A 96 percent open area media support grid of welded wire construction, coated with rust inhibitor shall be bonded to the air exiting side of the filter. The enclosing frame shall be of high wet-strength beverage board with diagonal support members bonded to the air entering and air exiting side of each pleat. The inside periphery of the enclosing frame shall be bonded to the filter pack. A test report corresponding to each of the aforementioned ASHRAE Standards are required submittals. Provide filters with characteristics as follows:

<table>
<thead>
<tr>
<th>Minimum MERV Rating Per ASHRAE Std. 52.2</th>
<th>Filter Depth</th>
<th>Sq Ft Media Per Sq Ft Face Area</th>
<th>Pleats Per Linear Foot</th>
<th>Initial Resistance in Inch, wg</th>
</tr>
</thead>
<tbody>
<tr>
<td>MERV 7</td>
<td>2&quot;</td>
<td>4.6</td>
<td>15</td>
<td>0.30 @ 500 fpm</td>
</tr>
<tr>
<td>MERV 7</td>
<td>4&quot;</td>
<td>7.0</td>
<td>11</td>
<td>0.27 @ 500 fpm</td>
</tr>
</tbody>
</table>

   B. Each filter shall also consist of an enclosing frame with channels for insertion into a 1 inch deep filter track. The enclosing frame shall include integral reinforced headers on the top and bottom.
C. High Efficiency Final Filter: Air filters shall be high performance, 12 inches deep pleated, totally rigid and disposable type. Media shall be wet-laid micro-fiberglass with separators to maintain pleat uniformity and spacing. Frame shall be a high impact plastic with built in header on top and bottom. Media shall be adhered and sealed to frame with polyurethane to prevent by-pass. Filters shall be classified by Underwriters’ Laboratories as Class 2. The filter shall be capable of withstanding 10 inches w.g. resistance without distortion of media pack. Filters shall have a recommended final resistance of 2.0 inches w.g. Provide filters with characteristics as follows:

<table>
<thead>
<tr>
<th>Minimum MERV Rating Per ASHRAE Std. 52.2</th>
<th>Initial Resistance in Inch, wg</th>
</tr>
</thead>
<tbody>
<tr>
<td>MERV 11</td>
<td>0.20 @ 500 FPM</td>
</tr>
<tr>
<td>MERV 14</td>
<td>0.28 @ 500 FPM</td>
</tr>
<tr>
<td>MERV 15</td>
<td>0.34 @ 500 FPM</td>
</tr>
<tr>
<td>MERV 16</td>
<td>0.61 @ 500 FPM</td>
</tr>
</tbody>
</table>

D. Activated Carbon Filters: Provide factory-fabricated activated carbon filters with housings; where shown, in sizes and ratings indicated. Construct housing of 16-ga galvanized steel designed for side servicing through gasketed access doors on both sides. Equip housings with lightweight trays containing activated carbon on metal slide channel tracks. Construct separately removable carbon cell trays of 26-ga epoxy coated perforated steel and steel framing. Construct carbon cell holding frames of 14-ga epoxy coated steel; seal each unit to prevent unfiltered air by-pass. Construct units with capacity of not less than 45 lbs. of activated carbon per 1000 cfm of air flow. Provide filters with rated face velocity of 500 fpm, and resistance of 0.50 inch w.g.

E. High Efficiency Particulate Air (HEPA-) Filters: HEPA grade standard capacity air filters with waterproof micro glass fiber media, corrugated aluminum separators, urethane sealant, a galvannealed 16-gauge steel enclosing frame and sealing gasket. Filter media shall be one continuous pleating of micro fine glass fiber media. Pleats shall be uniformly separated by corrugated aluminum separators incorporating a hemmed edge to prevent damage to the media. The media pack shall be potted into the enclosing frame with a fire-retardant urethane sealant. The enclosing frame shall be of galvannealed 16-gauge steel and shall be bonded to the media pack. The filter shall be assembled without the use of fasteners to ensure no frame penetrations. Overall dimensional tolerance shall be correct within – 1/8", +0", and square within 1/8". A pored-in-place seamless sealing gasket shall be included on the downstream side of the enclosing frame to form a positive seal upon installation. The filter shall have a tested efficiency of (99.97%, 99.99%, 99.999%) when evaluated according to IEST Recommended Practice. Initial resistance to airflow shall not exceed 1.0" w.g. mat rated capacity. Filter shall be rated by Underwriters Laboratories as UL Class 1. The filter shall be capable of withstanding 10" w.g. without failure of the media pack.

1. Allowable Nominal Sizes (inches):
   a. 24x12x6
   b. 24x24x6
   c. 24x12x12
   d. 24x24x12
2.3 FILTER HOLDING SYSTEMS

A. Front and Rear Access Filter Frames: Provide filter bank framing system, constructed of aluminum framing members having minimum thickness of 0.09 inch. Design system for either upstream (front) or downstream (rear) filter servicing. Cut to size and pre-punch members for easy assembly into modules of size and capacity as scheduled or noted on drawings. Provide permanently gasketed framing members to prevent bypass of unfiltered air. If vertical support members are required to prevent deflection of horizontal members, install so as not to interfere with either installation or operation of filters. Incorporate separate track for prefilters, removable from front, or removable from back after removal of after-filters. Provide factory-installed positive sealing device for each row of filters, to insure seal between gasketed filter elements. Provide hardware necessary for field assembly.

B. Side Servicing Housings: Provide factory-assembled side servicing housings with flanges for insertion into ductwork system as indicated. Construct of 14-ga [painted galvanized steel][304 stainless steel]. Provide integral pre-filter tracks to accommodate 2-inch throw-away or cleanable filters. Provide access doors with continuous gasketing on perimeter and positive locking devices. Incorporate positive-sealing gasket material on channels to seal filter cartridge frames to prevent bypass. Arrange so filter cartridges can be loaded from either access door.

C. Side Servicing Bag In/Bag Out Housings: Provide factory-assembled side servicing housings with flanges for insertion into ductwork system as indicated. Construct of 14-ga [painted galvanized steel][304 stainless steel]. Housing shall be factory tested to +10 inches w.c. in accordance with ANSI/ASME N509 and N510 to ensure overall housing integrity. Provide integral pre-filter tracks to accommodate 2-inch throw-away or cleanable filters. Provide access doors with continuous gasketing on perimeter and positive locking devices. Incorporate positive-sealing gasket material on channels to seal filter cartridge frames to prevent bypass. Arrange so filter cartridges can be loaded from either access door. [Provide low leakage isolation damper on upstream and downstream sides of housing.]

2.4 FILTER GAGES

A. Description: Diaphragm type with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Diameter: [4-1/2 inches (115 mm)].
2. Range: 0- to 3.0-inch wg (0 to 750 Pa).

B. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install filter frames according to manufacturer’s written instructions.

B. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

C. Install filters in position to prevent passage of unfiltered air.

D. Install filter gage for each filter bank.

E. Install filter gage static-pressure tips upstream and downstream from filters to measure pressure drop through filter. Mount filter gages on outside of filter housing or filter plenum in an accessible position.

F. Coordinate filter installations with duct and air-handling unit installations.

PARTICULATE AIR FILTRATION
G. Ground equipment according to Division 26 Section "Grounding and Bonding."
H. Provide differential pressure sensors for each set of filter efficiencies separately.

3.2 FIELD QUALITY CONTROL
A. HEPA Filters: Pressurize housing to a minimum of 3.0-inch wg (750 Pa) or to designed operating pressure, whichever is higher; and test housing joints, door seals, and sealing edges of filter for air leaks according to ASME N510 pressure-decay method.

3.3 CLEANING
A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 234100
SECTION 235216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, [pulse-combustion] [fire-tube] [water-tube] [water-jacketed] condensing boilers, trim, and accessories for generating [hot water] [steam].

1.3 PERFORMANCE REQUIREMENTS
   A. Seismic Performance: Withstand the effects of seismic forces determined by Division 23 Section "Vibration, Seismic, and Wind Controls for HVAC."

1.4 SUBMITTALS
   A. General: Submit the following in accordance with Division 23 Section "Common Work Results for HVAC."

1.5 ACTION SUBMITTALS
   A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
   B. Shop Drawings:
      1. Layout Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.

1.6 INFORMATIONAL SUBMITTALS
   A. Qualification Data:
      1. Source quality-control test reports.
      2. Special Warranty: Special warranty specified in this Section.
   B. Field Quality Control Test Reports.
   C. Other Informational Submittals:
      1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.

1.7 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.
1.8 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
   C. ASHRAE/IESNA 90.1-[2007][2010] Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
   E. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

1.9 COORDINATION
   A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.10 WARRANTY
   A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.
      1. Warranty Period for Pulse-Combustion Boilers:
         a. Heat Exchanger Damaged by Thermal Shock: [10] <Insert number> years from date of Substantial Completion.
         b. Heat-Exchanger Corrosion: [Prorated] [Nonprorated] for [five] <Insert number> years from date of Substantial Completion.
      2. Warranty Period for Fire-Tube Condensing Boilers:
         a. Leakage and Materials: [10] <Insert number> years from date of Substantial Completion.
         b. Heat Exchanger Damaged by Thermal Stress and Corrosion: [Prorated] [Nonprorated] for [five] <Insert number> years from date of Substantial Completion.
      3. Warranty Period for Water-Tube Condensing Boilers: [20] <Insert number> years from date of Substantial Completion.
      4. Warranty Period for Water-Jacketed Condensing Boilers:
         a. Leakage and Materials: [Eight] <Insert number> years from date of Substantial Completion.
         b. Heat Exchanger Damaged by Thermal Stress and Corrosion: [Prorated] [Nonprorated] for [five] <Insert number> years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide [the product indicated on Drawings] <Insert manufacturer's name; product name or designation> or a comparable product by one of the following:

1. AERCO International.
2. Camus
3. Raypak
4. Harsco Industrial, Patterson-Kelley
5. Lochinvar Corporation.
6. <Insert manufacturer's name.>

2.2 MANUFACTURED UNITS

A. Description: Factory-fabricated, -assembled, and -tested, pulse-combustion condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.

B. Heat Exchanger: [Type 316L, stainless-steel] [Carbon-steel] primary and secondary combustion chamber.

C. Pressure Vessel: Carbon steel with welded heads and tube connections.

D. Exhaust Decoupler: Fiberglass composite material in a corrosion-resistant steel box.

E. Burner: [Natural] [Propane] gas, self-aspirating and self-venting after initial start.

F. Blower: Centrifugal fan to operate only during start of each burner sequence.

   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

G. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

H. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

I. Casing:

   1. Jacket: Sheet metal, with snap-in or interlocking closures.
   2. Control Compartment Enclosure: NEMA 250, Type 1A.
   4. Insulation: Minimum 2-inch (50-mm-) thick, mineral-fiber insulation surrounding the heat exchanger.
   5. Draft Hood: [Integral] [External].
   6. Combustion-Air Connection: Inlet duct collar and sheet metal closure over burner compartment.
   7. Mounting base to secure boiler to concrete base.

J. Mufflers: Carbon-steel intake muffler and stainless-steel exhaust.
K. Condensate Trap: Cast-iron body with stainless-steel internal parts.

L. Characteristics and Capacities: Refer to Drawings.
   2. Design Water Pressure Rating: [15 psig (104 kPa)] [150 psig (1035 kPa)] <Insert pressure rating>.
   3. Safety Relief Valve Setting: <Insert psig (kPa)>.

2.3 MANUFACTURED UNITS

A. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.

B. Heat Exchanger: Nonferrous, corrosion-resistant combustion chamber.

C. Pressure Vessel: Carbon steel with welded heads and tube connections.

D. Burner: [Natural] [Propane] gas, forced draft.

E. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.
   1. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
      a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

F. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

G. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

H. Casing:
   1. Jacket: [Sheet metal] [Plastic], with snap-in or interlocking closures.
   2. Control Compartment Enclosures: NEMA 250, Type 1A.
   4. Insulation: Minimum 2-inch- (50-mm-) thick, [mineral-fiber] [polyurethane-foam] insulation surrounding the heat exchanger.
   6. Mounting base to secure boiler.

I. Characteristics and Capacities: Refer to Drawings.
   2. Design Water Pressure Rating: [160 psig (1100 kPa)] <Insert value>.
   3. Safety Relief Valve Setting: <Insert psig (kPa)>.

2.4 MANUFACTURED UNITS

A. Description: Factory-fabricated, -assembled, and -tested, water-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.

B. Heat Exchanger: Finned-copper primary and stainless-steel secondary heat exchangers.
C. Combustion Chamber: Stainless steel, sealed.

D. Burner: [Natural] [Propane] gas, forced draft drawing from gas premixing valve.

E. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.
   1. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
      a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

F. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

G. Ignition: Silicone carbide hot-surface ignition that includes flame safety supervision and 100 percent main-valve shutoff.

H. Integral Circulator: Cast-iron body and stainless-steel impeller sized for minimum flow required in heat exchanger.

I. Casing:
   1. Jacket: Sheet metal, with snap-in or interlocking closures.
   2. Control Compartment Enclosures: NEMA 250, Type 1A.
   4. Insulation: Minimum [1-inch-(25-mm)-] [2-inch-(50-mm)-] thick, mineral-fiber insulation surrounding the heat exchanger.
   6. Mounting base to secure boiler.

J. Characteristics and Capacities: Refer to Drawings.
   2. Design Water Pressure Rating: [160 psig (1100 kPa)] <Insert value>.
   3. Safety Relief Valve Setting: <Insert psig (kPa).>

2.5 MANUFACTURED UNITS

A. Description: Factory-fabricated, -assembled, and -tested, water-jacketed condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; water supply, return, and condensate drain connections; and controls. Water heating service only.

B. Heat Exchanger: Stainless-steel primary and secondary combustion chamber.

C. Pressure Vessel: Carbon steel with welded heads and tube connections where not in contact with combustion or flue gases.

D. Burner: [Natural] [Propane] gas, forced draft; swing-open front and burner observation port.

E. Blower: Centrifugal fan, forced draft. Include prepurge and postpurge of the combustion chamber.
   1. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
      a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
F. Gas Train: Combination gas valve with manual shutoff and pressure regulator. Include 100 percent safety shutoff with electronic flame supervision.

G. Ignition: Electric-spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

H. Casing:
1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
4. Insulation: Minimum 4-inch- (100-mm-) thick, mineral-fiber insulation surrounding the heat exchanger.
6. Mounting base to secure boiler.

I. Characteristics and Capacities: Refer to Drawings.
2. Design Water Pressure Rating: $[30 \text{ psig (207 kPa)}] <\text{Insert value}>.$
3. Safety Relief Valve Setting: $<\text{Insert psig (kPa).}>$

2.6 TRIM
A. Include devices sized to comply with [ANSI B31.1, "Power Piping] [ANSI B31.9, " Building Services Piping]."
B. Aquastat Controllers: Operating, firing rate, and high limit.
C. Safety Relief Valve: ASME rated.
D. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
E. Boiler Air Vent: [Automatic] [Manual].
G. Circulation Pump: Non-overloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.

2.7 CONTROLS
A. Refer to Division 23 Section "Instrumentation and Control for HVAC."
B. Boiler operating controls shall include the following devices and features:
1. Control transformer.
2. Set-Point Adjust: Set points shall be adjustable.
3. Operating Pressure Control: Factory wired and mounted to cycle burner.
4. Low-Water Cutoff and Pump Control: Cycle feedwater pump(s) for makeup water control.
5. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
6. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At \([0 \text{ deg F (minus 17 deg C)}} < \text{<Insert temperature}>\) outside-air temperature, set supply-water temperature at \([200 \text{ deg F (93 deg C)}} < \text{<Insert temperature}>\); at \([60 \text{ deg F (15 deg C)}} < \text{<Insert temperature}>\) outside-air temperature, set supply-water temperature at \([140 \text{ deg F (60 deg C)}} < \text{<Insert temperature}>\).
   a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

C. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
   1. High Cutoff: \([\text{Manual} [\text{Automatic}] \text{ reset stops burner if operating conditions rise above maximum boiler design \text{temperature} \text{[pressure]}}\).
   2. Low-Water Cutoff Switch(s): \([\text{Electronic} [\text{Float and electronic}] \text{ probe shall prevent burner operation on low water. Cutoff switch shall be \text{manual} [\text{automatic}-\text{reset type. Auxiliary low cutoff shall be \text{manual} [\text{automatic} \text{reset}}]]\).
   4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

D. Building Management System Interface: Factory install hardware and software to enable building management system to monitor, control, and display boiler status and alarms.
   1. Hardwired Points:
      a. Monitoring: On/off status, \([\text{common trouble alarm} [\text{low water level alarm} < \text{<Insert monitoring}>] \text{.}\)
      b. Control: On/off operation, \([\text{hot water supply temperature set-point adjustment} < \text{<Insert control}>] \text{.}\)
   2. A communication interface with building management system shall enable building management system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building management system.

2.8 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
   1. House in NEMA 250, Type [1] \(<\text{<Insert type}>\) enclosure.
   2. Wiring shall be numbered and color-coded to match wiring diagram.
   3. Install factory wiring outside of an enclosure in a metal raceway.
   4. Field power interface shall be to \([\text{wire lugs} [\text{fused disconnect switch}] [\text{nonfused disconnect switch}] [\text{circuit breaker}]\).
   5. Provide branch power circuit to each motor and to controls\([\text{with a disconnect switch or circuit breaker}]\).
   6. Provide each motor with overcurrent protection.
2.9 VENTING KITS
   A. Kit: Complete system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.
   B. Combustion-Air Intake: Complete system, stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

2.10 SOURCE QUALITY CONTROL
   A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
   B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
   C. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
      1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
   B. Examine mechanical spaces for suitable conditions where boilers will be installed.
   C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION
   A. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.
   B. Vibration Isolation[ and Seismic Restraint]: Vibration isolation and restraint devices and installation requirements are specified in Division 23 Section "Vibration, Seismic, and Wind Controls for HVAC."
   C. Install gas-fired boilers according to NFPA 54.
   D. Assemble and install boiler trim.
   E. Install electrical devices furnished with boiler but not specified to be factory mounted.
   F. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS
   A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
   B. Install piping adjacent to boiler to allow service and maintenance.
C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Division 23 Section "Common Work Results for HVAC."

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

H. Boiler Venting:
   1. Install flue venting kit and combustion-air intake. Properly pitch piping towards boiler.
   2. Connect full size to boiler connections.[Comply with requirements in Division 23 Section "Breechings, Chimneys, and Stacks."

I. Ground equipment according to Division 26 Section "Grounding and Bonding."

J. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Perform installation and startup checks according to manufacturer's written instructions.
   2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
   3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
      a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and [water temperature] [steam pressure].
      b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Occupancy Adjustments: When requested within [12 months of date of Substantial Completion] <Insert time period>, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two] <Insert number> visits to Project during other than normal occupancy hours for this purpose.

E. Performance Tests:
   1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
   2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.
   a. Test for full capacity.
   b. Test for boiler efficiency at [low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20] <Insert range> percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.

3.5 DEMONSTRATION

A. [Engage a factory-authorized service representative to train] [Train] Owner's maintenance personnel to adjust, operate, and maintain boilers.[ Video training sessions.] Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 235216
SECTION 235700 - HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Extent of heat exchangers work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of heat exchangers specified in this section include the following:
   1. Steam-to-water U-tube heat exchangers.
   2. Water-to-water U-tube heat exchangers.
   5. Steam to steam exchangers (clean steam).

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Tube-removal and general maintenance space.
   2. Structural members to which heat exchangers will be attached.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, performance, and dimensional requirements of heat exchangers and are based on the specific equipment indicated. Refer to Division 01 Section "Product Requirements."

B. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

C. Registration: Fabricate and label shell-and-tube heat exchangers to comply with the Tubular Exchanger Manufacturers Association’s standards.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 STEAM-TO-WATER U-TUBE HEAT EXCHANGERS

A. General: Provide steam-to-water U-tube heat exchangers as indicated, of capacity as scheduled on the Drawings, and as specified herein. Minimum fouling factor shall be 0.00075.

B. Type: Shell and tube, U-bend removable tube bundle, steam in shell, water in tubes, equipped with mounting legs.

C. Materials:
   1. Shell: Steel.
   2. Tubes: 3/4 inch O.D. seamless copper, 0.035" thick.
   3. Heads: Cast iron or steel.
   4. Tube Sheets: Steel.
   5. Tube Supports: Steel.

D. Construction: ASME construction for 125 psi design pressure at 375 deg. F.

E. Manufacturers: Subject to compliance with requirements, provide steam-to-water U-tube heat exchangers of one of the following:
   1. Armstrong Pumps, Inc.
   2. Bell & Gossett ITT.

2.3 WATER-TO-WATER U-TUBE HEAT EXCHANGERS

A. General: Provide water-to-water U-tube heat exchangers as indicated, of capacity as scheduled on the Drawings, and as specified herein. Minimum fouling factor shall be 0.00075.

B. Type: Shell and tube, U-bend removable tube bundle, heating water in shell, heated water in tubes.

C. Materials:
   1. Shell: Steel.
   2. Tubes: 3/4 inch O.D. seamless copper, 0.035" thick.
   3. Heads: Cast iron or steel.
   4. Tube Sheets: Steel.

D. Construction: ASME construction for 125 psi design pressure at 300 deg. F.

E. Manufacturers: Subject to compliance with requirements, provide water-to-water U-tube heat exchangers of one of the following:
   1. Armstrong Pumps, Inc.
   2. Bell & Gossett ITT; Fluid Handling Div.
2.4 GASKETED PLATE HEAT EXCHANGERS

A. General: Provide gasketed plate heat exchangers as indicated, of capacity as scheduled on the Drawings, and as specified herein. Minimum fouling factor shall be 0.00075.

B. Configuration: Freestanding assembly consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets.

C. Frame:
   1. Capacity to accommodate 20 percent additional plates.
   2. Painted carbon steel with provisions for anchoring to support.

D. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.

E. End-Plate Material: Painted carbon steel.

F. Tie Rods and Nuts: Steel or stainless steel.

G. Plate Material: Minimum 0.024 inch (0.6 mm) thick before stamping; Type 304L stainless steel.

H. Gasket Material: Nitrile rubber or EPDM.

I. Piping Connections:
   1. Threaded port for NPS 2 (DN 50) and smaller. For larger sizes, furnish end-plate port with threaded studs suitable for flanged connection.
   2. End plate with welded carbon-steel nozzles. Threaded pipe connection for NPS 2 (DN 50) and smaller; carbon-steel flanged pipe connection for larger sizes.
   3. Line wetted surfaces with same material as plates.

J. Enclose plates in a solid aluminum or stainless-steel removable shroud.

K. Manufacturers:
   1. Alfa Laval Thermal, Inc.
   2. Advanced Industrial Components,
   3. Baltimore Air Coil Co.
   4. ITT Industries; Bell & Gossett.
   5. Tranter PHE, Inc.

2.5 BRAZED PLATE HEAT EXCHANGERS

A. General: Provide brazed plate heat exchangers as indicated, of capacity as scheduled on the Drawings, and as specified herein. Minimum fouling factor shall be 0.00075.

B. Configuration: Brazed assembly consisting of two end plates, one with threaded nozzles and pattern-embossed plates.

C. End-Plate Material: Type 304 or Type 316 stainless steel.

D. Threaded Nozzles: Type 304 or Type 316 stainless steel.

E. Plate Material: Type 304 or Type 316 stainless steel.

F. Brazing Material: Copper or nickel.

G. Manufacturers:
   1. Alfa Laval Thermal, Inc.
   2. Armstrong Pumps, Inc.
2.6 STEAM TO STEAM EXCHANGERS (CLEAN STEAM)

A. General: Provide steam-to-steam generators as indicated, of capacity as scheduled on the drawings, and as specified herein.

B. Construction: Unfired Steam Generator shall be ASME Code constructed and stamped in accordance with Section VIII, Division 1, for Unfired Steam Generators for 150 PSIG. Unfired Steam Generators shall be registered with the National Board of Boiler and Pressure Vessel Inspectors, and signed copy of shop inspection report shall be furnished. Unfired Steam Generator shall be built in accordance with Section VII, "Unfired Steam Generators" and shall bear the "UB" stamp. Unfired Steam Generator subject to steam side shall be 304 grade stainless steel. Unfired Steam Generator shall be insulated with not less than 2 inches of fiberglass insulation, protected by 20 gage thick minimum enameled steel jacket. Unfired Steam Generator shall be mounted on a suitable I-Beam support skid which shall be permanently welded to the shell. Submerged coil shall be a copper tube bundle. Trim copper and steel.

C. Generator shall be provided with the following factory mounted and piped components:

1. Controller: Output steam pressure shall be maintained by a modulating source steam valve which monitors the output steam pressure and varies the input of source steam to maintain a constant output steam pressure. A pneumatically operated steam controller shall be used to monitor the output steam pressure and send a varying air signal to the source steam controller to modulate the flow of source steam and maintain a constant output steam pressure. Pneumatic set point is field adjustable. Provide strainer ahead of control valve.

2. Dual float and thermostatic traps, one for the coil and one for the drip before the control valve.

3. Outlet steam strainer and moisture separator.

4. ASME Code pressure relief valve with a capacity to relieve the total BTU of output of the generator.

5. Heating Element: The heating element shall be ASME stamped for at least 100% of the working pressure of the heating medium. The heating element shall be a U-tube design with a cast iron or ASME code steel removable front head. If the heating element weighs over 200 lbs, it shall be provided with support rails or installed so that it rides on the bottom of the shell with the shell seam welds ground smooth.

6. Distribution: If the outlet steam temperature exceeds the makeup feed water temperature by more than 100 degrees F, a distributor shall be supplied on the inlet.

7. Gage Glass: The gage glass shall be designed for ASME steam service and shall clearly show the range from below the low water cut-off to above the high limit level.

8. Outlet steam gauge and inlet pressure vacuum gauge.

9. Electronic level control.

10. Water level with tri-cocks.


12. Electric Safety System: Consisting of an alarm bell and electric shut-off of incoming source steam via solenoid on pilot or incoming air signal. This safety system is designed to prevent the unfired steam generator from generating steam above the desired set point. Provide dry contacts for alarm interface with the Building Automation System.

13. Feed Water Solenoid Valve: Consisting of a solenoid valve shall automatically open and close to allow the water level in the tank to be maintained at the correct level. This feed water solenoid valve shall be electrically operated.
14. Pressure Control (may not be required with low pressure input boiler steam). Pressure control shall consist of an air operated, fully modulating steam pressure controller operating a proportional, pneumatic, single seated, normally closed control valve. This shall be backed up by an independent steam pressure safety system to automatically shut off the steam.

D. Manufacturers: Subject to compliance with the requirements, provide steam-to-steam generator of one of the following:
   1. Cemline Corporation.
   2. Patterson Kelley, Inc.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.
      1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 HEAT-EXCHANGER INSTALLATION
   A. Install shell-and-tube heat exchangers on saddle supports.
   B. Mounting: Mount heat exchangers on trapeze hangers as indicated, located for required clearance for tube removal.
   C. Install shell-and-tube heat exchangers on concrete base. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.
   D. Install heat exchanger with restraints required by Division 23 Section "Vibration Controls for HVAC."
   E. Concrete Bases: Anchor heat exchanger to concrete base.
      1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
      2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
      3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
      4. Install anchor bolts to elevations required for proper attachment to supported equipment.
      5. Cast-in-place concrete materials and placement requirements are specified in Division 03.
      6. Mounting: Mount heat exchangers on floor housekeeping pads as indicated, located for required clearance for disassembly and/or tube bundle removal.

3.3 CONNECTIONS
   A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
   B. Maintain manufacturer's recommended clearances for service and maintenance. Install piping connections to allow service and maintenance of heat exchangers.
   C. Install shutoff valves at heat-exchanger inlet and outlet connections.

HEAT EXCHANGERS FOR HVAC 235700 - 5

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D. Install pressure gauges at inlet and outlet connections.
E. Install temperature gauges at hydronic inlet and outlet connections.
F. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.
G. Install vacuum breaker at heat-exchanger steam inlet connection.
H. Install hose end valve to drain shell.
I. Pipe blowdown to nearest floor drain.

3.4 FIELD QUALITY CONTROL
A. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 CLEANING
A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 SPARE PARTS
A. General: Furnish to Owner, with receipt, one spare gasket for each flanged connection for each heat exchanger.

3.7 DEMONSTRATION
A. Train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 235700
SECTION 236423 - SCROLL WATER CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Extent of scroll chiller work required by this Section is indicated on Drawings and Schedules, and by requirements of this Section.
   B. Section Includes:
      1. Packaged, water-cooled, electric-motor-driven, scroll water chillers.
      2. Packaged, air-cooled, electric-motor-driven, scroll water chillers.
      3. Packaged refrigerant recovery units.

1.3 DEFINITIONS
   A. COP: Coefficient of Performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
   B. EER: Energy-Efficiency Ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
   C. IPLV: Integrated Part-Load Value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.
   D. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
   E. NPLV: Nonstandard Part-Load Value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than the ARI standard rating conditions.

1.4 PERFORMANCE REQUIREMENTS
   A. [Seismic] [and] [Wind] Performance: Scroll water chillers shall withstand the effects of [seismic] [and] [wind] forces determined according to the requirements of Division 23 Section "Vibration, Seismic, and Wind Controls for HVAC."

1.5 SUBMITTALS
   A. General: Submit the following in accordance with Division 23 Section "Common Work Results for HVAC."

1.6 ACTION SUBMITTALS
   A. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
      1. Performance at ARI standard conditions and at conditions indicated.
      2. Performance at ARI standard unloading conditions.
      3. Minimum evaporator flow rate.
      4. Refrigerant capacity of water chiller.
5. Oil capacity of water chiller.
6. Fluid capacity of evaporator.
7. Fluid capacity of condenser.
9. Minimum entering condenser-water temperature.
10. Performance at varying capacity with constant design condenser-water temperature. Repeat performance at varying capacity for different condenser-water temperatures from design to minimum in [5 deg F (3 deg C)] <Insert deg F (deg C)> increments.
11. Minimum entering condenser-air temperature.
12. Performance at varying capacity with constant design entering condenser-air temperature. Repeat performance at varying capacity for different entering condenser-air temperatures from design to minimum in [10 deg F (6 deg C)] <Insert deg F (deg C)> increments.

B. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Wiring Diagrams: For power, signal, and control wiring.

C. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

D. Certificates: For certification required in "Quality Assurance" Article.

1.7 INFORMATIONAL SUBMITTALS

A. Source Quality Control Test Reports.

B. Startup service reports.

1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.

1. Special Warranty Information: Sample of special warranty.

1.9 QUALITY ASSURANCE

A. ARI Certification: Certify chiller according to ARI 590 certification program.

B. ARI Rating: Rate water chiller performance according to requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."

C. ASHRAE Compliance:

1. ASHRAE 15 for safety code for mechanical refrigeration.
2. ASHRAE Guideline 3 for refrigerant leaks, recovery, and handling and storage requirements.

D. NEC Compliance: Comply with applicable NEC requirements pertaining to electrical power and control wiring for construction and installation of scroll chillers.

E. ANSI Compliance: Comply with ANSI B9.1 safety code requirements pertaining to unit construction of scroll chillers.

F. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.

G. Comply with NFPA 70.

H. UL Compliance: Comply with applicable requirements of UL465, "Central Cooling Air Conditioners" pertaining to construction and installation of scroll chillers. Provide scroll chillers that are UL listed and labeled.

I. Nationally Recognized Testing Laboratory (NRTL) and NEMA Compliance: Scroll chillers shall be listed and labeled by a NRTC. The term "NRTL" shall be as defined in OSHA.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.

B. Package water chiller for export shipping.

1.11 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate sizes, locations, and anchoring attachments of structural steel support structures.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.12 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within specified period.

1. Compressor Warranty Period: [Five (5)] <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PACKAGED WATER-COOLED WATER CHILLERS

A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide [the product indicated on Drawings] <Insert manufacturer's name; product name or designation> or a comparable product by one of the following:

1. Daikin Applied
2. Trane.

SCROLL WATER CHILLERS

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3. Carrier.
4. Johnson Controls, Inc.
5. <Insert manufacturer's name>.

C. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.

D. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.

E. Compressors:
   1. Description: Positive-displacement direct drive with hermetically sealed casing.
   2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
   3. Operating Speed: Nominal 3600 rpm for 60 Hz applications.
   4. Capacity Control: On-off compressor cycling, [plus hot-gas bypass] [if required for unloading down to 10 percent].
   5. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, initial oil charge, and crankcase oil heater.
   7. Sound-reduction package shall consist of acoustic enclosures or compressor blanket around the compressors that are designed to reduce sound level without affecting performance.

F. Compressor Motors:
   1. Hermetically sealed and cooled by refrigerant suction gas.
   2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.

G. Compressor Motor Controllers:
   1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

H. Refrigeration:
   1. Refrigerant: R-410A. Classified as Safety Group A1 according to ASHRAE 34.
   2. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
   3. Refrigerant Circuit: Each circuit shall include a thermal-expansion valve, refrigerant charging connections, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
   4. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

I. Evaporator:
   1. Brazed-plate or shell-and-tube design, as indicated.
   2. Shell and Tube:
      a. Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
      b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
c. Shell Material: Carbon steel.

d. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.

e. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.

f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

3. Brazed Plate:

a. Direct-expansion, single-pass, brazed-plate design.

b. Type 316L stainless steel construction.

c. Code Compliance: Tested and stamped for a refrigerant side working pressure of 450 psig minimum and a waterside working pressure of 300 psi minimum according to ASME Boiler and Pressure Vessel Code.

d. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.

e. Air vent and drain fittings are to be added in the field piping near the connections.

J. Condenser:

1. Shell and tube or without integral condenser; as indicated.

2. Shell and Tube:

a. Description: Shell-and-tube design with refrigerant flowing through the shell and fluid flowing through the tubes within the shell.

b. Provides positive subcooling of liquid refrigerant.

c. Code Compliance: Tested and stamped according to ASME Section VIII Pressure Vessel Code and ANSI B9.1 Safety Code.


e. Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping.

f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

g. Provide each condenser with an ASME pressure relief device, purge cock, and liquid-line shutoff valve.

3. Provide water chiller without an integral condenser and design chiller for field connection to remote condenser. Coordinate requirements with Division 23 Section “Air-Cooled Refrigerant Condensers.”

K. Electrical Power:

1. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.

2. House in a unit-mounted, NEMA 250, [Type 1] <Insert type> enclosure with hinged access door with lock and key or padlock and key.

3. Wiring shall be numbered and color-coded to match wiring diagram.

4. Install factory wiring outside of an enclosure in a raceway.

5. Field power interface shall be to [wire lugs] [NEMA KS 1, heavy-duty, nonfused disconnect switch].
6. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
   a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
   b. NEMA KS 1, heavy-duty, nonfusible switch.
   c. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

7. Provide each motor with overcurrent protection.
8. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
10. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
11. Control Relays: Auxiliary and adjustable time-delay relays.
12. Indicate the following for water chiller electrical power supply:
   a. Current, phase to phase, for all three phases.
   b. Voltage, phase to phase and phase to neutral for all three phases.
   c. Three-phase real power (kilowatts).
   d. Three-phase reactive power (kilovolt amperes reactive).
   e. Power factor.
   f. Running log of total power versus time (kilowatt hours).
   g. Fault log, with time and date of each.
   h. <Insert features>.

L. Controls:
   1. Standalone, microprocessor based.
   2. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
   3. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:
      a. Date and time.
      b. Operating or alarm status.
      c. Operating hours.
      d. Outside-air temperature if required for chilled-water reset.
      e. Temperature and pressure of operating setpoints.
      f. Entering and leaving temperatures of chilled water.
      g. Entering and leaving temperatures of condenser water.
      h. Refrigerant pressures in evaporator and condenser.
      i. Saturation temperature in evaporator and condenser.
      j. No cooling load condition.
      k. Elapsed time meter (compressor run status).
      l. Pump status.
      m. Antirecycling timer status.
      n. Percent of maximum motor amperage.
      o. Current-limit setpoint.
      p. Number of compressor starts.
      q. <Insert items>.
4. Control Functions:
   a. Manual or automatic startup and shutdown time schedule.
   b. Entering and leaving chilled-water temperatures, control setpoints, and motor load limit. Chilled-water leaving temperature shall be reset based on [return-water][outside-air][space] temperature.
   c. Current limit and demand limit.
   d. Condenser-water temperature.
   e. External water chiller emergency stop.
   f. Antirecycling timer.
   g. Automatic lead-lag switching.
   h. Continuous diagnostic check of unit.
   i. <Insert functions>.

5. Manual Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
   a. Low evaporator pressure or high condenser pressure.
   b. Low chilled-water temperature.
   c. Refrigerant high pressure.
   d. High or low oil pressure.
   e. High oil temperature.
   f. Loss of chilled-water flow.
   g. Loss of condenser-water flow.
   h. Control device failure.
   i. Low ambient lockout.
   j. <Insert items>.

6. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor, control, and display water chiller status and alarms.
   a. Hardwired Points:
      1) Monitoring: On/off status, [common trouble alarm] [electrical power demand (kilowatts)] [electrical power consumption (kilowatt hours)] <Insert monitoring point>.
      2) Control: On/off operation, [chilled-water discharge temperature set-point adjustment] [electrical power demand limit] <Insert control point>.
   b. [ASHRAE 135 (BACnet)] [LonTalk] [LonMark] [Industry-accepted open-protocol] <Insert type of interface> communication interface with building management system shall enable building management system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building management system.

M. Insulation:
   1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
   2. Thickness: [3/4 inch (19 mm)] <Insert thickness>.
   3. Factory-applied insulation over cold surfaces of water chiller components.
      a. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
4. Apply protective coating to exposed surfaces of insulation.

N. Accessories:
   1. Factory-furnished, chilled-[and condenser]-water flow switches for field installation.
   2. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
   3. Factory-furnished [neoprene] [spring] [neoprene or spring] isolators for field installation.

O. Capacities, Characteristics, and Efficiencies: Refer to Drawings.

2.2 PACKAGED AIR-COOLED WATER CHILLERS

A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
   1. Carrier Corporation; a United Technologies company.
   2. Trane.
   3. Johnson Controls, Inc.
   4. [Insert manufacturer's name].

B. Basis-of-Design Product: Subject to compliance with requirements, provide [the product indicated on Drawings] [Insert manufacturer's name; product name or designation] or a comparable product by one of the following:
   1. Carrier Corporation; a United Technologies company.
   2. Trane.
   3. Johnson Controls, Inc.
   4. [Insert manufacturer's name].

C. Description: Factory-assembled and run-tested water chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.

D. Fabricate base, frame, and attachment to water chiller components strong enough to resist movement during a seismic event when water chiller base is anchored to field support structure.

E. Cabinet:
   1. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
   2. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
   4. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a [500] [Insert hours]-hour salt-spray test according to ASTM B 117.
   5. Sound-reduction package consisting of the following:
      a. Acoustic enclosure around compressors.
      b. Reduced-speed fans with acoustic treatment.
      c. Designed to reduce sound level without affecting performance.
   6. Security Package: Provide security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access.

F. Compressors:
   1. Description: Positive displacement direct drive with hermetically sealed casing.
   2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
   3. Operating Speed: Nominal 3600 rpm for 60 Hz applications.
5. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.

G. Compressor Motors:
1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.

H. Compressor Motor Controllers:
1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

I. Refrigeration:
1. Refrigerant: [R-407c] [R-410a]. Classified as Safety Group A1 according to ASHRAE 34.
2. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
3. Refrigerant Circuit: Each circuit shall include a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
4. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

J. Evaporator:
1. Brazed-plate or shell-and-tube design, as indicated.
2. Shell and Tube:
   a. Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
   b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
   c. Shell Material: Carbon steel.
   d. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
   e. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
   f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
3. Brazed Plate:
   a. Direct-expansion, single-pass, brazed-plate design.
   b. Type 316 stainless steel construction.
   c. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
   d. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
4. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F (minus 29 deg C).
5. **Remote Mounting:** Designed for remote field mounting where indicated. Provide kit for field installation.

K. **Air-Cooled Condenser:**
   1. Plate-fin coil with integral subcooling on each circuit, rated at 450 psig (3103 kPa).
      a. Construct coils of copper tubes mechanically bonded to [aluminum with precoated epoxy-phenolic] [copper] fins.
      b. Coat coils with a baked epoxy corrosion-resistant coating after fabrication.
      c. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
   2. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
   3. Fan Motors: Totally enclosed non-ventilating (TENV) or totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.
   4. Fan Guards: Steel safety guards with corrosion-resistant coating.

L. **Electrical Power:**
   1. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
   2. House in a unit-mounted, NEMA 250, [Type 3R] <Insert type> enclosure with hinged access door with lock and key or padlock and key.
   3. Wiring shall be numbered and color-coded to match wiring diagram.
   4. Install factory wiring outside of an enclosure in a raceway.
   5. Field power interface shall be to [wire lugs] [NEMA KS 1, heavy-duty, nonfused disconnect switch].
   6. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
      a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
      b. NEMA KS 1, heavy-duty, nonfusible switch.
      c. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
   7. Provide each motor with overcurrent protection.
   8. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
   10. Provide power factor correction capacitors to correct power factor to [0.90] [0.95] <Insert value> at full load.
   11. Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
      a. Power unit-mounted controls where indicated.
      b. Power unit-mounted, ground fault interrupt (GFI) duplex receptacle.
   13. Indicate the following for water chiller electrical power supply:
      a. Current, phase to phase, for all three phases.
      b. Voltage, phase to phase and phase to neutral for all three phases.
      c. Three-phase real power (kilowatts).
d. Three-phase reactive power (kilovolt amperes reactive).

e. Power factor.

f. Running log of total power versus time (kilowatt hours).

g. Fault log, with time and date of each.

h. <Insert features>.

M. Controls:

1. Standalone, microprocessor based.

2. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.

3. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:

a. Date and time.

b. Operating or alarm status.

c. Operating hours.

d. Outside-air temperature if required for chilled-water reset.

e. Temperature and pressure of operating setpoints.

f. Entering and leaving temperatures of chilled water.

g. Refrigerant pressures in evaporator and condenser.

h. Saturation temperature in evaporator and condenser.

i. No cooling load condition.

j. Elapsed time meter (compressor run status).

k. Pump status.

l. Antirecycling timer status.

m. Percent of maximum motor amperage.

n. Current-limit setpoint.

o. Number of compressor starts.

p. <Insert items>.

4. Control Functions:

a. Manual or automatic startup and shutdown time schedule.

b. Entering and leaving chilled-water temperatures, control setpoints, and motor load limit. Chilled-water leaving temperature shall be reset based on [return-water][outside-air][space] temperature.

c. Current limit and demand limit.

d. External water chiller emergency stop.

e. Antirecycling timer.

f. Automatic lead-lag switching.

g. Continuous diagnostic check of unit.

h. <Insert functions>.

5. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:

a. Low evaporator pressure or high condenser pressure.

b. Low chilled-water temperature.

c. Refrigerant high pressure.

d. High or low oil pressure.

e. High oil temperature.

f. Loss of chilled-water flow.

g. Control device failure.
h. Low ambient lockout.
   i. <Insert items>.

6. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor, control, and display water chiller status and alarms.
   a. Hardwired Points:
      1) Monitoring: On/off status, [common trouble alarm] [electrical power demand (kilowatts)] [electrical power consumption (kilowatt hours)]
         <Insert monitoring point>.
      2) Control: On/off operation, [chilled-water discharge temperature set-point adjustment] [electrical power demand limit] <Insert control point>.
   b. [ASHRAE 135 (BACnet)] [LonTalk] [LonMark] [Modbus] [Industry-accepted open-protocol] <Insert type of interface> communication interface with building management system shall enable building management system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building management system.

N. Insulation:
   1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
   2. Thickness: [3/4 inch (19 mm)] [1-1/2 inches (38 mm)] <Insert thickness>.
   3. Factory-applied insulation over cold surfaces of water chiller components.
      a. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
   4. Apply protective coating to exposed surfaces of insulation.

O. Accessories:
   1. Factory-furnished, chilled-[and condenser]-water flow switches for field installation.
   2. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
   3. Factory-furnished [neoprene] [spring] [neoprene or spring] isolators for field installation.

P. Capacities, Characteristics, and Efficiencies: Refer to Drawings.

2.3 PACKAGED REFRIGERANT RECOVERY UNITS
   A. Packaged portable unit shall consist of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit shall be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest water chiller.

2.4 SOURCE QUALITY CONTROL
   A. Perform functional test of water chillers before shipping.
B. Factory performance test water chillers, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
   1. Allow [Owner] <Insert entity> access to place where water chillers are being tested. Notify Architect [14] <Insert number> days in advance of testing.

C. Factory test and inspect evaporator [and water-cooled condenser] according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

D. For water chillers located indoors, rate sound power level according to ARI 575 procedure.

E. For water chillers located outdoors, rate sound power level according to ARI 370 procedure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.
   1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WATER CHILLER INSTALLATION

A. Install water chillers on support structure indicated. Comply with requirements for vibration isolation, [seismic] [and] [wind] devices specified in Division 23 Section "Vibration, Seismic, and Wind Controls for HVAC."

B. Equipment Mounting: Install water chiller on concrete bases. Comply with requirements in Division 03 Section "[Cast-in-Place Concrete] [Miscellaneous Cast-in-Place Concrete]." Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration, Seismic, and Wind Controls for HVAC."
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Maintain manufacturer's recommended clearances for service and maintenance.

D. Charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.

E. Install separate devices furnished by manufacturer and not factory installed.

3.3 CONNECTIONS

A. Comply with requirements in Division 23 Section "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Division 23 Section "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
C. Install piping adjacent to chiller to allow service and maintenance.

D. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, [strainer,] [flexible connector,] thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, [flexible connector,] flow switch, thermometer, plugged tee with pressure gage, [flow meter,] and drain connection with valve. Make connections to water chiller with a [union, flange, mechanical coupling, union, flange, or mechanical coupling].

E. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, [strainer,] [flexible connector,] thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, [flexible connector,] flow switch, thermometer, plugged tee with pressure gage, [flow meter,] and drain connection with valve. Make connections to water chiller with a [union, flange, mechanical coupling, union, flange, or mechanical coupling].

F. Refrigerant Pressure Relief Valve Connections: For water chillers installed indoors, extend vent piping to the outside without valves or restrictions. [Comply with ASHRAE 15.]

G. Connect each drain connection with a union and drain pipe and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection if required.

3.4 STARTUP SERVICE

A. [Engage a factory-authorized service representative to perform] [Perform] startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
   2. Verify that pumps are installed and functional.
   3. Verify that thermometers and gages are installed.
   4. Operate water chiller for run-in period.
   5. Check bearing lubrication and oil levels.
   6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
   7. Verify proper motor rotation.
   8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
  11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Prepare a written startup report that records results of tests and inspections.

3.5 DEMONSTRATION

A. [Engage a factory-authorized service representative to train] [Train] Owner's maintenance personnel to adjust, operate, and maintain water chillers. [Video record the training sessions.]

END OF SECTION 236423
SECTION 236426 - ROTARY-SCREW WATER CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. This Section includes packaged, water-cooled, electric-motor-driven, rotary-screw water chillers with the following features:
   1. Motor controller.

1.3 DEFINITIONS
A. EER: Energy-efficiency ratio.
B. IPLV: Integrated part-load value.

1.4 PERFORMANCE REQUIREMENTS
A. Seismic Performance: Rotary-screw water chillers shall withstand the effects of forces determined according to the requirements of Division 23 Section Vibration, Seismic, and Wind Controls for HVAC.

1.5 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Common Work Results for HVAC."

1.6 ACTION SUBMITTALS
A. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
B. Shop Drawings: Complete set of manufacturer's certified prints of water chiller assemblies, control panels, sections, and elevations, and unit isolation. Include the following:
   1. Assembled unit dimensions.
   2. Operating weight and load distribution.
   3. Required clearances for maintenance and operation.
   4. Size and location of piping and wiring connections.
C. Coordination Drawings: Floor plans drawn to scale and coordinated with the following:
   1. Structural supports.
   2. Piping roughing-in requirements.
   3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
   4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.
D. Certificates: For certification required in "Quality Assurance" Article.
1.7 INFORMATIONAL SUBMITTALS
A. Source Quality Control Test Reports.
B. Startup service reports.

1.8 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For each water chiller to include in emergency, operation and maintenance manual.
   1. Special Warranty Information: Special warranties specified in this Section.

1.9 QUALITY ASSURANCE
A. ARI Certification: Signed by manufacturer certifying compliance with requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
B. ASHRAE Certification: Signed by manufacturer certifying compliance with ASHRAE 15 for safety code for mechanical refrigeration. Comply with ASHRAE Guideline 3 for refrigerant leaks, recovery, and handling and storage requirements.
C. ASME Compliance: Fabricate and label water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
D. Comply with NFPA 70.
E. Comply with UL 1995.

1.10 DELIVERY, STORAGE, AND HANDLING
A. Ship water chillers from the factory fully charged with refrigerant or nitrogen.

1.11 COORDINATION
A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
B. Coordinate installation of roof curbs and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.12 WARRANTY
A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carrier; a United Technologies Company.
2. Daikin Applied Trane Company (The).
3. Johnson Controls, Inc.
4. <Insert manufacturer's name.>

2.2 PACKAGED WATER CHILLERS

A. Description: Factory-assembled and -tested water chiller complete with compressor, evaporator, condenser, controls, interconnecting unit piping and wiring, indicated accessories, and mounting frame.

B. Description: Factory-assembled and -tested water chiller complete with compressor, heat exchanger, and controls integrated with compressor operation.

C. Description: Factory-assembled and -tested water chiller complete with casing, compressor, heat exchanger, condenser coils and fans, and controls integrated with compressor operation.

2. Fans: Propeller type, statically and dynamically balanced, with vertical air discharge for high efficiency and low sound; located in its own compartment to eliminate cross flow of condenser air during fan cycling; and equipped with heavy-gage, weather-protected fan guard.
3. Fan Motor: Direct drive, weatherproof, with bearings permanently lubricated, and having built-in current- and thermal-overload protection.

D. Fabricate water chiller mounting frame and attachment to the pressure vessel with reinforcement strong enough to resist water chiller movement during a seismic event when the water chiller mounting frame is anchored to the building structure.

2.3 COMPRESSORS

A. Description: Positive displacement, oil injected with direct-drive, [open] [hermetically sealed] motor.

1. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
2. Rotors: [Single] [Twin] screw.

B. Capacity Control: Hydraulically operated, modulating or stepped sliding valve to maintain chilled-water temperature set point without hunting within throttling range. Throttling range shall be from 100 to [10] [20] percent of full load.

C. Oil Lubrication System: Positive-displacement submersible pump with heater, oil filter, and sight glass.

D. Refrigerant and Oil: [HFC-134a] [R-407c] [R-410a] [HFC-134a, R-407c, or R-410a].

E. Refrigerant Compatibility: Seals, O-rings[, motor windings,] and internal water chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

F. Refrigerant Circuit: <Insert number> independent circuits. Each circuit shall include [a thermal] [an electronic] expansion valve, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter drier, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
2.4 HEAT EXCHANGERS

A. Evaporator:
   1. Description: Shell-and-tube design, ASME labeled.
   3. Tube Construction: Individually replaceable, expanded into tube sheets.
      a. Material: Copper.
   4. Water Box: [Standard] [Marine], with design working pressure of [150 psig (1035 kPa)] [300 psig (2070 kPa)], and having [flanged] [grooved mechanical-joint coupling] water-nozzle connections with a thermistor-type temperature sensor factory installed in each nozzle.

B. Condenser:
   1. Description: Shell-and-tube design, ASME labeled.
   3. Tube Construction: Externally enhanced and individually replaceable, expanded into tube sheets.
      a. Material: Copper.
      b. Minimum Size: 3/4-inch (19-mm) OD; 0.028-inch (0.71-mm) wall thickness.
      c. Internal Finish: [Enhanced] [Smooth].
   4. Water Box: [Standard] [Marine], with design working pressure of [150 psig (1035 kPa)] [300 psig (2070 kPa)], and having [flanged] [grooved mechanical-joint coupling] water-nozzle connections with a thermistor-type temperature sensor factory installed in each nozzle.

C. Air-Cooled Condenser: Copper tubes with mechanically bonded [aluminum] [copper] fins [with corrosion-resistant coating], integral subcooling circuit, leak tested at 450 psig (3105 kPa).
   1. Safety and Operating Options: Low-ambient controls for operation down to <Insert temperature>.

2.5 INSULATION

A. Cold Surfaces: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type II, for sheet materials.
   1. Thickness: 1-1/2 inches (38 mm).
   2. Adhesive: As recommended by insulation manufacturer.
   3. Factory apply insulation over entire surfaces of water chiller components.
      a. Apply adhesive to 100 percent of insulation contact surface.
      b. Seal seams and joints.
      c. After adhesive has fully cured, apply two coats of protective coating to insulation.

2.6 ACCESSORIES

A. Pressure Relief Valve: Single- or multiple-reseating-type, spring-loaded relief valve.

2.7 CONTROLS

A. Control Panel: Stand-alone, microprocessor based.
B. Enclosure: Unit-mounted, NEMA 250, Type [1] [3R] [12] <Insert type> enclosure, hinged or lockable; factory wired with a single-point power connection and a separate control circuit.

C. Status Display: Multiple-character liquid-crystal display or light-emitting diodes and keypad. Display the following conditions:
   1. Date and time.
   2. Operating or alarm status.
   3. Operating hours.
   4. Outside-air temperature if required for chilled-water reset.
   5. Temperature and pressure of operating set points.
   6. Entering and leaving temperatures of chilled water.
   7. Entering and leaving temperatures of condenser water (for water-cooled water chillers only).
   8. Refrigerant pressures in evaporator and condenser.
   9. Saturation temperature in evaporator and condenser.
  10. Oil temperature and pressure.
  13. Number of compressor starts.
  14. <Insert other status display items.>

D. Control Functions:
   1. Manual or automatic startup and shutdown time schedule.
   2. Entering and leaving chilled-water temperature, control set points, and motor load limit. Chilled-water temperature shall be reset based on [return-water] [outside-air] [space] temperature.
   3. Current limit and demand limit.
   4. Condenser-water temperature.
   5. External water chiller emergency stop.
   6. <Insert other control functions.>

E. Manually Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
   1. Low evaporator [pressure] [temperature]; high condenser pressure.
   2. Low chilled-water temperature.
   3. Low oil differential pressure.
   4. High or low oil pressure.
   5. High oil temperature.
   6. High compressor-discharge temperature.
   7. Loss of chilled- or condenser-water flow.
   8. Electrical overload.
   9. Sensor- or detection-circuit fault.
  11. Starter fault.
  12. <Insert other reset safety control items.>

F. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor and control chilled-water set point and all chiller-control displays and alarms.
2.8 MOTORS
A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   1. Open-drive motors shall have flanged or flexible coupling suitable for direct connection to compressor.

2.9 MAGNETIC ENCLOSED CONTROLLERS
A. Enclosure: Unit mounted, [NEMA 250] [NEMA ICS 6], Type [1] [3R] [4] [12], with hinged access door with lock and key or padlock and key.
B. Control Circuit: 120 V; obtained from [integral control power transformer] <Insert source of control power> with a control power [transformer] [source] of enough capacity to operate connected pilot and indicating and control devices.
C. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of water chiller control microprocessor.
D. Star-Delta Controller: NEMA ICS 2, closed transition.
E. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.
   1. Surge suppressor in solid-state power circuits providing 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
   2. Light-emitting-diode indicators showing motor and control status, including the following conditions:
      a. Controller on.
      b. Overload trip.
      c. Loss of phase.
      d. Starter fault.
F. Accessories: Devices shall be factory installed in controller enclosure, unless otherwise indicated.
   1. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
      a. Selectable, digital display of the following:
         1) Phase Currents, Each Phase: Plus or minus 1 percent.
         2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
         3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
         4) Three-Phase Real Power: Plus or minus 2 percent.
         5) Three-Phase Reactive Power: Plus or minus 2 percent.
         6) Power Factor: Plus or minus 2 percent.
         7) Frequency: Plus or minus 0.5 percent.
         8) Integrated Demand with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
         9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
      b. Mounting: Display and control unit flush or semirecessed in instrument compartment door.
   2. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hard-wired connections.
2.10 SOURCE QUALITY CONTROL

A. Factory test and rate water chillers, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle." Stamp with ARI label.

B. Factory test heat exchangers hydrostatically at 1.50 times the design pressure.

C. Factory test and inspect evaporator and water-cooled condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

D. Factory test and inspect water boxes at 150 percent of working pressure.

E. Rate sound power level according to ARI 575 procedure.

F. Rate sound power level according to ARI 370 procedure.

G. Allow Owner access to places where water chillers are being source quality-control tested. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before water chiller installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, piping, and electrical to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.

   1. Final water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WATER CHILLER INSTALLATION

A. Install water chillers on concrete base. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.

B. Concrete Bases: Anchor chiller mounting frame to concrete base.

   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.

   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

   4. Install anchor bolts to elevations required for proper attachment to supported equipment.

   5. Cast-in-place concrete materials and placement requirements are specified in Division 03.

C. Vibration Isolation[ and Seismic][Wind] Restraint: Vibration isolation and restraint devices and installation requirements are specified in Division 23 Section "Vibration, Seismic, and Wind Controls for HVAC."

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Charge water chiller with refrigerant if not factory charged.

F. Install separate devices furnished by manufacturer.
3.3 CONNECTIONS

A. Chilled- and condenser-water piping installation requirements are specified in Division 23 Section "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to chiller to allow service and maintenance. No piping shall be installed above chiller.

C. Evaporator Connections: Connect inlet to evaporator with controller-bulb well, shutoff valve, thermometer, strainer, pressure gage, and union or flange. Connect outlet to evaporator with shutoff valve, flow switch, balancing valve, thermometer, pressure gage, and union or flange.

D. Condenser Connections: Connect inlet to condenser with shutoff valve, thermometer, plugged tee, and pressure gage. Connect outlet to condenser with shutoff valve, thermometer, drain line and shutoff valve, strainer, and plugged tee.

E. Refrigerant Pressure Relief Valve Connections: Extend vent piping to the outside without valves or restrictions.

F. Ground water chillers according to Division 26 Section "Grounding and Bonding."

G. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

H. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period according to manufacturer's written instructions.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief is vented outside (for water-cooled water chillers).
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Prepare a written startup report that records results of tests and inspections.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose.
3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 236426
SECTION 237200 - AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY
A. Section Includes:
   1. Heat wheels.
   3. Fixed-plate sensible heat exchangers.
   4. Packaged energy recovery units.

1.2 PERFORMANCE REQUIREMENTS
A. Delegated Design: Design vibration isolation and wind restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
B. Wind Performance: Air-to-air energy recovery equipment shall withstand the effects of wind forces determined according to the requirements of Division 23 Section "Vibration Controls for HVAC."

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product indicated. Include rated capacities, furnished specialties, and accessories.
B. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.
   1. Layout Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.
C. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which equipment or suspension systems will be attached.

1.5 INFORMATIONAL SUBMITTALS
A. Field Quality Control Reports.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.
1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ARI Compliance: Capacity ratings for air-to-air energy recovery equipment shall comply with the latest edition of ARI 1060, "Rating Air-to-Air Energy Recovery Equipment."

C. ASHRAE Compliance:
   1. Applicable requirements in ASHRAE 62.1-2007, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
   2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."

D. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.

E. UL Compliance: Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."

1.8 COORDINATION

A. Coordinate layout and installation of air-to-air energy recovery equipment and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Packaged Energy Recovery Units: Two years.
   2. Warranty Period for Fixed-Plate Total Heat Exchangers: 10 years.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: One set(s) of each type of filter specified.
   2. Fan Belts: One set(s) of belts for each belt-driven fan in energy recovery units.
   3. Wheel Belts: One set(s) of belts for each heat wheel.

PART 2 - PRODUCTS

2.1 HEAT WHEELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Loren Cook Company.
B. Casing:
1. Steel with standard factory-painted finish.
2. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa) differential pressure.
3. Casing seals on periphery of rotor and on duct divider and purge section.

C. Rotor: Aluminum segmented wheel strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating.
1. Maximum Solid Size for Media to Pass: 800 micrometer.

D. Rotor: Polymer segmented wheel strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating.
1. Maximum Solid Size for Media to Pass: 800 micrometer.

E. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable frequency controller and self-adjusting multilink belt around outside of rotor.
1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section “Common Motor Requirements for HVAC Equipment.”
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

F. Controls:
1. Variable frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing and air differential temperature above set point. Provide maximum rotor speed when exhaust-air temperature is less than outdoor-air temperature.

G. Extended-Surface, Disposable Panel Filters:
1. Comply with NFPA 90A.
2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
3. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
5. Thickness: 2 inches (50 mm).
6. Initial Resistance: 0.3 inches wg.
7. Recommended Final Resistance: 1.0 inches wg.
9. Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.
11. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

2.2 HEAT-PIPE HEAT EXCHANGERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Applied Air; a company of Mestek Technology Inc.
   2. Engineered Air.

B. Casing: Galvanized-steel flanged casing, with airtight partition between airstreams.

C. Refrigerant: ASHRAE 15, Group 1.

D. Tubes: 5/8-inch- (16-mm-) or 1-inch- (25-mm-) diameter, copper.
   1. Fin Spacing: The fins shall be no more than 10 fins per inch.
   2. Fin and Tube Joint: Mechanical bond.

E. Coating: [Thermoplastic vinyl] [Epoxy] [Synthetic resin] [Phenolic] [Polytetrafluoroethylene] [Vinyl ester] <Insert coating>; apply to supply and exhaust.

F. Control: Integral plenum containing heat-pipe coil and gasketed, face-and-bypass, opposed-blade dampers with rods extended outside casing for damper operator and linkage.

2.3 FIXED-PLATE SENSIBLE HEAT EXCHANGERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Nutech Brands, Inc.
   3. RenewAire, LLC.
   4. United Air Specialists, Inc.; a CLARCOR company.

B. Casing: Aluminum with duct collars.

C. Casing Insulation: 1 inch (25 mm) thick, fiber free.
   1. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.

D. Drain Pan: Same material as casing, with drain connections on exhaust and supply side.

E. Plates: Evenly spaced and sealed and arranged for counter airflow.
   1. Plate Material: Embossed aluminum or Stainless steel.
   2. Plate Coating: [Epoxy] [Air-dried phenolic].

F. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.
G. Water Wash: Automatic system, with spray manifold to individual spray tubes or traversing type with stainless-steel-screw operating mechanism and electric motor drive; activated by time clock.

H. Extended-Surface, Disposable Panel Filters:
   1. Comply with NFPA 90A.
   2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   3. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
   5. Thickness: 2 inches (50 mm).
   6. Initial Resistance: 0.3 inches wg.
   7. Recommended Final Resistance: 1.0 inches wg.
   8. MERV (ASHRAE 52.2): 7.
   9. Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.
   11. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

2.4 PACKAGED ENERGY RECOVERY UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Applied Air; a company of Mestek Technology Inc.
   2. Des Champs Technologies.
   3. Engineered Air.
   5. Greenheck Fan Corporation.
   7. Mitsubishi Electric & Electronics USA, Inc.; HVAC Advanced Products Division.
   8. RenewAire, LLC.
   9. SEMCO Incorporated.
   10. Trane; American Standard, Inc.
   11. Venmar CES Inc.
   12. Wing, L. J.; Mestek Technology, Inc.

B. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, hinged access doors or removable panels with neoprene gaskets for inspection and access to internal parts, minimum 2-inch-thick thermal insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.
   1. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.
   2. Inlet: Weatherproof hood, with damper for exhaust and supply.
   3. Roof Curb: Refer to Division 07 Section "Roof Accessories" for roof curbs and equipment supports.

D. Supply and Exhaust Fans: Backward-inclined, SWSI centrifugal or Backward-inclined, plenum centrifugal fan with spring isolators and insulated flexible duct connections.
   1. Motor and Drive: Drive type indicated on Drawings.
   2. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
   5. Spring isolators on each fan having 1-inch static deflection.

E. Extended-Surface, Disposable Panel Filters:
   1. Comply with NFPA 90A.
   2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   3. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
   5. Thickness: 2 inches (50 mm).
   6. Initial Resistance: 0.3 inches wg.
   7. Recommended Final Resistance: 1.0 inches wg.
   8. MERV (ASHRAE 52.2): 7.
   9. Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.
   11. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

F. Piping and Wiring: Fabricate units with space within housing for piping and electrical conduits. Wire motors and controls so only external connections are required during installation.
   1. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
   2. Outdoor Enclosure: NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
   3. Include fused disconnect switches.
   4. Variable-speed controller to vary fan capacity from 100 to approximately 30 percent.

G. Accessories:
   1. Roof Curb: Galvanized steel or Aluminum with gasketing, and factory-installed wood nailer; complying with NRCA standards; minimum height of 24 inches.
   2. Intake weather hood with 2-inch- (50-mm-) thick filters.
   3. Exhaust weather hood with birdscreen.
4. Low-Leakage, Isolation Dampers: Double-skin, airfoil-blade, extruded-aluminum dampers with compressible jamb seals and extruded-vinyl blade edge seals, in opposed-blade arrangement with cadmium-plated steel operating rods rotating in sintered bronze bearings mounted in a single extruded-aluminum frame, with operating rods connected with a common linkage, and electric damper operator factory wired. Leakage rate shall not exceed 5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).

5. Duct flanges.
7. Hinged access doors with quarter-turn latches.
10. Weatherproofing for tilt-control system.

2.5 CONTROLS

A. Time Clock: Solid-state, programmable, microprocessor-based unit for mounting in outdoor NEMA 250, Type 3R enclosure with up to eight on/off cycles per day and battery backup protection of program settings against power failure to energize unit.

B. Carbon Monoxide Sensor: Adjustable control from 600 to 2000 ppm for duct mounting with digital display and computer/building management system interface to energize unit.

C. Humidistat: Adjustable, wall-mounted instrument to energize unit when space relative humidity exceeds 50 percent.

2.6 CAPACITIES AND CHARACTERISTICS

A. Refer to Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install heat wheels so supply and exhaust airstreams flow in opposite directions and rotation is away from exhaust side to purge section to supply side.

1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.

2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.

3. Access doors and panels are specified in Division 23 Section "Air Duct Accessories."
B. Install heat-pipe heat exchangers so supply and exhaust airstreams flow in opposite directions. Install flexible connectors on ducts to enable tilt control; make connections airtight and with slack to compensate for full tilt.
   1. Install heat exchanger with clearance space for heat-pipe coil removal.
   2. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to both sides of heat-pipe coil. Access doors and panels are specified in Division 23 Section "Air Duct Accessories."
   3. Install tilt-control components, including electronic controller, electric actuator and linkage, thermostats, and sensors.

C. Install fixed-plate heat exchangers so supply and exhaust airstreams flow in opposite directions.
   1. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to heat exchanger. Access doors and panels are specified in Division 23 Section "Air Duct Accessories."

D. Equipment Mounting: Install air-to-air energy recovery equipment on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-Place Concrete."
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

E. Roof Curb: Install on roof structure or concrete base, level and secure, according to ARI Guideline B. Install air-to-air energy recovery equipment on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 07 Section "Roof Accessories." Secure air-to-air energy recovery equipment to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

F. Install wind restraints according to Division 23 Section "Vibration Controls for HVAC."

G. Suspended Units: Suspend units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration Controls for HVAC."

H. Install units with clearances for service and maintenance.

I. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

J. Pipe drains from units and drain pans to nearest floor drain; use; same size as condensate drain connection.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Division 23 Section "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for ductwork specified in Division 23 Section "Metal Ducts."

C. Install piping adjacent to machine to allow service and maintenance.
3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Adjust seals and purge.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   4. Set initial temperature and humidity set points.
   5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION 237200
PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes constant-volume and variable volume, central station air handling units with coils for indoor installations.

1.2 PERFORMANCE REQUIREMENTS
   A. Delegated Design: Design vibration isolation details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
   B. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of L/200 where "L" is the unsupported span length within completed casings.
   C. NOTE TO SPECIFIER: Review spare capacity requirements during the design effort based on input from Froedtert staff and the use of the spaces served by the air handling equipment.

1.3 SUBMITTALS
   A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS
   A. Refer to Division 23 Section "Basic Mechanical Requirements."
   B. Certification Letter:
      1. Product certificates signed by manufacturers of central-station air-handling units certifying that their products comply with specified requirements.
   C. Product Data: For each air-handling unit indicated.
      1. Unit dimensions and weight, including unit plan, elevation views, all internal components, wall and floor penetrations, structural frame design, and unit weights at lifting lugs.
      2. Cabinet material, metal thickness, finishes, insulation, and accessories.
      3. Panel joint(s) and panel details showing thermal breaks.
      5. Shipping split connections details.
      6. Fans:
         a. Certified fan-performance curves with system operating conditions indicated. Provide static pressure calculation including internal component pressure losses, system effect losses and available external static pressure.
         b. Certified sound power ratings at unit discharge and return connections, and maximum casing radiated sound power levels.
         c. Fan construction and accessories.
         d. Motor ratings, electrical characteristics, and motor accessories.
      7. Certified coil-performance ratings with system operating conditions indicated. Also include matched condensing unit data for DX cooled units.
8. Where air blenders are shown on the Drawings, provide certified air blender performance.
9. Dampers, including housings, linkages, and operators.
10. Filters with performance characteristics.
11. Provide product data for all other accessory sections as indicated including, but not limited to: sound attenuators, variable frequency drives, humidifiers, heat recovery devices, internal lighting devices, flow and control devices, etc.

D. Shop Drawings:
   1. Wiring diagrams detailing wiring for power and controls and differentiating between manufacturer-installed wiring and field-installed wiring.
   2. Sustainability/Sustainable Credit Applicability:

E. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
   2. Support location, type, and weight.
   3. Field measurements.
   4. Shop drawings from manufacturer detailing dimensions, required clearances, components, and location and size of each field connection.

1.5 INFORMATIONAL SUBMITTALS
A. Qualification Data:
   1. Source Quality Control Reports.

B. Field Quality Control Reports. Submit field quality control test report specified in Part 3 of this specification section.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals as specified in Division 01 and Division 23 Section "Basic Mechanical Requirements."

1.7 QUALITY ASSURANCE
A. Source Limitations: Obtain modular indoor air-handling units through one source from a single manufacturer.
B. All shipping splits must be joined at the factory to confirm proper alignment of all components before disassembly for shipping.
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
D. UL Compliance: Electric coils, along with the complete central-station air-handling unit, shall be listed and labeled by Underwriters' Laboratories.

MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS
E. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Electric coils, along with the complete central-station air-handling unit shall be listed and labeled by a NRTL. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

F. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

G. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

H. Comply with NFPA 70.

1.8 COORDINATION
A. Coordinate sizes and locations of concrete bases with actual equipment provided.
B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.9 DELIVERY, STORAGE, AND HANDLING
A. Refer to Division 23 Section "Common Work Results for HVAC."
B. Unit shall be shipped in a clear shrink-wrap or stretch-wrap to protect unit from in-transit rain, snow and debris per ASHRAE 62.1.
C. Lift and support units with the manufacturer's designated lifting or supporting points.
D. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.
E. Deliver central-station air-handling units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

1.10 EXTRA MATERIALS
A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: One set(s) for each air-handling unit.
   2. Gaskets: One set(s) for each access door.
   3. Fan Belts: One set(s) for each air-handling unit fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. CES Group, Inc.: Temtrol.
   2. Trane; American Standard, Inc.
   3. Johnson Controls, Inc.

2.2 MANUFACTURED UNITS
A. Modular indoor air-handling units shall be factory assembled and consist of fans, motor and drive assembly, coils, dampers, plenums, filters, condensate pans, mixing dampers, control devices and accessories. See drawings for additional AHU requirements.
B. Types: Central-station air-handling units included in this project are of the following types:
   1. Blow-through.
   2. Draw-through.

C. Motor and Electrical Components: Refer to Division 23 Section "Electrical Requirements for Mechanical Equipment."

2.3 UNIT CABINET

A. General Fabrication Requirements for Casings:
   1. Forming: Form walls, roofs, and floors with at least two thermal breaks at each joint.
   2. Casing Joints: Sheet metal screws or pop rivets.
   3. Sealing: Seal all joints with water-resistant sealant.

B. The unit casing in all component sections shall utilize a post-and-panel construction consisting of a heavy gauge galvanized steel or aluminum internal framework with bolted-on galvanized steel or aluminum panels. Removal of exterior panels shall not affect the structural integrity of the unit. All module to module joints and bolted panels shall be gasketed to minimize casing leakage.

C. Unit leakage shall meet or exceed the following SMACNA leakage classifications. Unit manufacturer shall provide test data after unit is fully constructed confirming cabinet construction meets these requirements in accordance with SMACNA test method and as calculated as noted in ASHRAE Standard 111 and AHRI 1350.
   1. Positive pressure: Class 6
   2. Negative pressure: Class 3

D. Unit shall be double wall construction in all sections including the unit walls, floors, and ceiling. Exterior walls shall be minimum 18 gauge galvanized steel or aluminum. Interior walls shall be minimum 22 gauge galvanized steel or aluminum. Interior walls shall be perforated in fan and sound attenuator sections. All other sections shall have a solid inner wall.
   1. Floors, ceilings and interior walls of all potentially wet sections shall be 304 stainless steel or aluminum. This includes sections containing heating coils, humidifiers, cooling coils, and supply fans, and the access sections between and immediately downstream of such components.
   2. Factory Finish for Galvanized-Steel or Aluminum Casings: Apply manufacturer's standard primer immediately after cleaning and pretreating.
   3. Factory Finish for Steel Casings: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of prime coat and thermosetting topcoat.

E. Structural reinforcement shall be designed so no member exceeds a deflection of 1/200 of span based on equipment loading and a differential static pressure of 6" w.c.

F. Floor and Base Construction:
   1. The floor plates shall be constructed of solid, 3/16" checker plate. Material shall be aluminum unless otherwise specified to be stainless steel.
   2. Floor panels shall be designed to support a 250 lb. load during maintenance activities and shall deflect no more than 1/240 of span.

G. Casing Insulation and Adhesive:
   1. Materials: ASTM C 1071 Type I or Type II with coated surface to prevent erosion of glass fibers.
2. Thickness:
   a. For units located inside: 2 inches (50 mm) R=7.7.
   b. For units located in unconditioned space: 4 inches (100 mm), R=15.6.

3. Thermal Conductivity (k-Value): 0.26 at 75 deg F (0.037 at 24 deg C) mean temperature.


5. Location and Application: Encased between outside and inside casing.

6. Fiberglass insulation shall not be exposed to the airstream. If any insulation is exposed, the installing contractor shall be responsible for covering it with 18 gauge galvanized steel or aluminum.

H. Inspection Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, double-wall insulated panels of same materials and thicknesses as casing.

2. Inspection Access Panels:
   a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
   b. Gasket: Neoprene, automotive type bulb gasketing applied around entire perimeters of panel frames.
   c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Access Doors:
   a. Hinges: A minimum of two ball-bearing hinges and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
   b. Gasket: Neoprene, automotive type bulb gasketing applied around entire perimeter of panel frames.
   c. Fabricate windows in doors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
   d. Size: At least 24 by 60 inches (600 by 1500 mm) unless indicated on plans. All doors located in fan sections shall be a minimum of 30” wide and 72” high.
   e. Center of window shall be approximately 48” above bottom of base rail.

4. Locations and Applications:
   a. Fan Section: Doors.
   b. Access Section: Doors.
   c. Coil Section: Doors.
   d. Mixing Box and Damper Section: Doors.
   e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
   f. And elsewhere as shown on Drawings.
I. Condensate Drain Pans:
   1. Double-Wall Drain Pans shall be furnished in all cooling coil sections, humidifier sections, and in any fan section immediately downstream of a cooling coil or humidifier section. Drain pans shall be of sealed double wall construction per ASHRAE 62.1 with the manufacturer’s standard insulation sandwiched between the pan layers. The interior wall shall be constructed of stainless steel. Drain pan shall be pitched in three directions.
   Drain connections (2” minimum) shall be provided on both sides of the unit. Units with stacked cooling coils shall have an intermediate drain pan, a drain trough, or some means of collecting condensate from the top coils and channeling it to the main unit drain pan.

J. Service Platform: Galvanized steel or aluminum, 42 inches (1070 mm) wide running entire length of unit and located on service access side, with angle side rails, 4-inch (100-mm) kick plates, and expanded metal floor.

K. Air-Handling-Unit Mounting Frame: Formed galvanized-steel or aluminum channel or structural channel supports, designed for low deflection and welded. Lifting lugs are to be removable after placement of equipment.

L. Base Rails: Furnish under complete unit. Base rails shall be fully-welded, 10 gauge structural steel, at least 6 inches high. Base rail to be of sufficient height to accommodate cooling coil condensate trap piping (and required tools) without extending below the plane of the bottom of the base rail.

2.4 FAN, DRIVE, AND MOTOR SECTION

A. Comply with requirements of Section 233416 Centrifugal HVAC Fans.

B. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower (Fan to be size, class, and type as indicated on the Drawings.)
   1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
      a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
      b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
      c. Fan wheel shall be properly secured to the shaft to prevent slippage.
   2. The fan, motor and V-belt drive assembly shall be mounted internally on a structural steel rail base and internally isolated with 2-inch deflection springs with side snubbers. In addition, the fan shall be internally flex connected to the fan section casing. For units with Backward Inclined or Air foil fan wheels, thrust restraints shall be provided.
   3. For variable speed applications, fans shall be dynamically balanced through entire range of operation.
   4. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled external static pressure. The motor furnished shall not operate into the motor service factor when operating under these conditions.
   5. Furnish galvanized mesh inlet screens for fans without inlet ductwork connections.
   6. When more than one fan is located in a fan section, provide each fan with a backdraft damper to prevent air flow through the fan when the fan is off.
7. Trolley Beams
   a. Provide:
      1) In fan sections where shown on the Drawings
      2) When any motor weighs 50 pounds or more.
      3) Bottom of motor is more than 60 inches above the floor of the air handling unit.
   b. Design and fabricate the unit housing and structural support system to support the weight of the trolley beam fully loaded with the weight of the fan motor, trolley and chain. Trolley beams shall be centered on access doors, or on removable component access panel, which shall be centered on fan motors. Beams shall be mounted at or near the ceiling of the fan compartment and shall extend continuously from interior wall to interior wall. Trolley, hoists, chainfalls and chain shall be provided “by others” in the future as needed.

C. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
   1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
   2. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.
   3. Flexible Connector: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) wide attached to 2 strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized-steel sheet or 0.032-inch- (0.8-mm-) thick aluminum sheets; select metal compatible with casing.
         1) Fabric Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
         2) Fabric Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
         3) Fabric Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

D. Plug Fans Housings: Steel cabinet; fabricated without fan scroll and volute housing.

E. Fan Shaft Bearings:
   1. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with a rated life of L-50, 200,000 hours according to ABMA 9.
   2. Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and 2-piece, cast-iron housing with grease lines extended to outside unit and a rated life of L-50, 200,000 hours according to ABMA 11.
   3. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit and a rated life of L-50, 200,000 hours.

F. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.2 service factor based on fan motor.
   1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   3. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives.
G. Belt Guards: Provide a metal belt guard for units with the motor mounted on outside of the casing. The belt guard shall be rigidly attached to the bearing support structure and have a two-piece removable front panel. A tach hole shall be provided opposite the fan shaft. Comply with requirements specified by OSHA and fabricate according to SMACNA’s "HVAC Duct Construction Standards"; 0.1046-inch (2.7-mm) thick, 3/4-inch (20-mm) diamond-mesh wire screen, welded to steel angle frame; prime coated.

H. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section “Common Motor Requirements for HVAC Equipment.
1. Enclosure Type: Totally enclosed, fan cooled.
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
4. Mount unit-mounted disconnect switches on interior of unit when motor is located inside the casing. Mount unit-mounted disconnect switches on exterior of unit when motor is located outside of the casing.

I. Variable Speed Controllers:
1. Refer to Division 23 Section "Electrical Requirements for Mechanical Equipment."

J. Fan-Section Source Quality Control:
1. Sound Criteria: The units shall not exceed the scheduled sound power ratings.
3. Factory test fan performance for flow rate, pressure, power, air density, rotation speed and efficiency. Establish ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

2.5 COIL SECTION
A. General Requirements for Coil Section:
1. Comply with ARI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
4. Coils shall not act as structural component of unit.
5. Coil sections shall be designed and constructed to facilitate the removal of coils from either the side or top of the unit for service or replacement. All coils shall be fully enclosed within the air handling unit casing. Coil headers and U-bends shall not be exposed. Coils shall be safed so as to assure full airflow through the coil without bypass. Units shall be tightly gasketed and sealed where coil connections penetrate through the casing to prevent air leakage. Provide coil connection on side of air handler as shown on plans.

B. Water (Glycol) Cooling and Heating Coils: Drainable, rigidly supported across the full face of the coil, and pitched to allow drainage. Waterflow shall be counter to airflow. Provide factory installed extended drain and vent connections to the exterior of the coil section.
1. Piping Connections: Threaded.
2. Tubes: Seamless copper, 5/8-inch OD, minimum 0.035-inch tube wall thickness.
3. Turbulators: Bronze, spring-type.
4. Fouling Factor: 0.00075.
5. Fins: 0.010 inches thick aluminum with fin spacing not less than 0.091 inch (2.54 mm).
6. Fin and Tube Joint: Mechanical bond.
7. Headers: Cast iron or copper with cleaning plugs and drain and air vent tappings.
8. Heating or Heat Recovery Coil Frames: Galvanized steel channel frame 0.0625 inch (1.58 mm).
9. Cooling Coil Frames: Stainless steel, 0.0625 inch (1.58 mm).
10. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
   a. Working Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).
11. Source Quality Control: Test to 300 psig (2070 kPa) and to 200 psig (1380 kPa) underwater.

C. Steam Coils: See Section 2.14 (INTEGRAL FACE AND BYPASS COIL SECTION) for requirements.

D. Direct-Expansion Refrigerant Coils: Designed and fabricated in compliance with ASHRAE Standard 15, "Safety Standard for Refrigeration Systems." Provide an equalizing Venturi-type refrigerant distributor, designed for low pressure drop, arranged for down feed with solder connections, and having a maximum of 12 circuits for each distributor. Coils with more than 12 circuits shall have two distributors. Split circuit coils shall have two distributors.
   1. Capacity Reduction: Circuit for [face] [row] [interleaved] control.
   3. Fins: [Aluminum 0.0075 inches thick] [Copper 0.0050 inches thick].
   5. Suction and Distributor: Seamless copper tube with brazed joints.
   6. Frames: Stainless steel, 0.0625 inch (1.58 mm).
   7. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
   8. Source Quality Control: Test to 450 psig (3105 kPa) and to 300 psig (2070 kPa) underwater.

2.6 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section:
   1. Comply with NFPA 90A.
   2. Provide minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   3. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
   4. Filter face velocities shall not exceed the value scheduled on the drawings. If not scheduled, the filter face velocity shall not exceed 500 fpm.
   5. Section shall have access doors on both sides of the unit.
   6. Filter sections shall include internal blockoffs as required to prevent air bypass around the filters.
   7. Refer to Division 23 Section "Particulate Air Filtration" for air filters required for air handling units.
B. Filter Gage:
   1. 3-1/2-inch- (90-mm-) diameter, diaphragm-actuated dial in metal case.
   2. Vent valves.
   3. Black figures on white background.
   4. Front recalibration adjustment.
   5. 2 percent of full-scale accuracy.
   6. Range: 0- to 4.0-inch wg (0 to 1000 Pa).
   7. Accessories: Static-pressure tips with integral compression fittings, 1/4-inch (6-mm) aluminum tubing, and 2- or 3-way vent valves.

2.7 DAMPERS
   A. Dampers and Damper Operators: Comply with requirements in Division 23 Section "Instrumentation and Control for HVAC."
   B. Face and Bypass Dampers: Opposed-blade galvanized steel dampers of airfoil design, with steel operating rods rotating in stainless steel sleeve bearings mounted in a single galvanized steel frame, and with operating rods connected together with a common linkage. Damper blades shall have metal compressible jamb seals and extruded vinyl edge seals, and shall be mechanically fastened to the operating rod. Bypass damper face area shall be at least 18 percent of entire face and bypass damper area to assure sufficient air mixing and low air pressure drops. Dampers shall be of low leak design, with leakage rate not to exceed 8 cfm/sq. ft. at 1.0 inch w.g. pressure differential.

2.8 HUMIDIFIER SECTION
   A. Comply with requirements in Division 23 Section "Humidifiers" (including separator, control valve and actuator and air flow switch).
   B. Provide full double wall drain pan in entire section.

2.9 AIR-TO-AIR ENERGY RECOVERY
   A. Comply with Division 23 Section "Air-to-Air Energy Recovery Equipment.

2.10 ACCESS SECTIONS
   A. Access sections shall be provided where shown on the plans. Access sections shall be of the length shown in the direction of airflow. Access sections shall be furnished by the air handling unit manufacturer, and shall be of the construction detailed under "Unit Cabinet." Access doors shall be provided on either one or both sides of the unit as indicated on the plans.

2.11 AIR BLENDER SECTION
   A. Air blender section shall be supplied where indicated on the drawings. Section shall incorporate factory installed access section upstream of the air blender, air blenders to minimize air stratification of the mixed air, and access section downstream of the blender. Casing for the air blender module shall be of the same construction as the other air handling unit sections. Access doors, constructed per "Unit Cabinet" Section, shall provide access to the interior of the module and the air blender. The air blender shall be a static mixing device, maintenance free and with no moving parts. It shall be constructed of heavy gauge galvanized steel.
B. Air blender and access sections shall be designed to provide thorough and accurate mixing of outside and return air throughout the outside air and supply air flow modulation regions such that the minimum mixed air temperature is at least 38 deg F. The air pressure drop across the air blender shall not exceed 0.15 inch w.g.

C. Overall length of the air handling unit shall be as shown on the Drawings.

D. Use Air Blender, Inc. unit where AHU manufacturer cannot meet size limitation.

2.12 SOUND ATTENUATOR SECTION

A. General: A sound attenuator section, furnished by the air handling unit manufacturer, shall be located where indicated on the Drawings. The casing shall be constructed in accordance with "Unit Cabinet" Section. The sound attenuator section shall be of double wall insulated construction with a perforated inner galvanized steel or aluminum wall. Silencers shall be factory or field installed in the sound attenuator section. Silencers shall be properly safed with galvanized sheet metal or aluminum within the casing to prevent air bypass. If the silencers are field installed within the sound attenuator section casing, the air handling unit manufacturer shall supervise installation of the silencers within the casing to assure the silencers are properly installed.

B. Sound Attenuators: Silencers shall be as scheduled on Drawings. They shall be sized for a maximum face velocity of 500 FPM. Dynamic insertion loss levels shall be no less than as scheduled on the plans.

2.13 DIFFUSER SECTION

A. If there is any coil section, filter section, or sound attenuator section located downstream of the supply fan, a diffuser section shall be furnished immediately after the supply fan section. The diffuser section shall be furnished by the air handling unit manufacturer, and shall be constructed per "Unit Cabinet" Section. A perforated galvanized steel or aluminum plate type diffuser, specially designed to give the airflow a near constant velocity profile, shall be factory installed within the section.

2.14 VERTICAL INTEGRAL FACE AND BYPASS COIL SECTION

A. Provide integral face and bypass coils of the quantities, sizes and capacities as shown on the schedule. Integral face and bypass coils shall consist of a built-in series of finned heating elements and by-passes with interlocked dampers. Finned elements shall be as scheduled, vertical tube coils. Horizontal tube coils are not acceptable.

B. Dampers shall be arranged to completely enclose and isolate the heating coil passes when no temperature rise is required. The dampers shall be 16 gauge (1.0 mm thick) roll formed steel and the coil casing shall be 14 gauge (1.1 mm thick) galvanized steel. The dampers and casing shall be coated with an air dried enamel finish. Airflow that passes through the dampers shall not vary more than 5 percent regardless of position of dampers.

C. Each coil shall be capable of maintaining a constant discharge air temperature regardless of variations in entering air temperatures and with full stream pressure or full hot water flow on the coil at all times. Each coil shall proportion the air such that the temperature at any point in a plane parallel to the face of the coil three feet downstream from the leaving side will not vary more than +5.0 degrees F (+2.8 degrees C) from the average discharge air stream thermostat setting.
D. Finned elements shall be fabricated out of 5/8 inch (15.9 mm) O.D. return blend type copper tubes with 0.035 inch (0.9 mm) wall thickness and rectangular aluminum fins of 0.010 inch (0.3 mm) thickness. Fins shall not be spaced closer than 12 fins per inch (12.1 fins per mm). Each tube shall be individually brazed into the supply and return headers with provision for individual tube expansion and contraction. Headers shall be 3 inch (76.5 m) SCH 40 pipe with 0.216 inch (5.5 mm) wall thickness. Each coil (using steam) shall have a single condensate outlet and single steam inlet. Finned elements shall be factory tested in accordance with ARI Standard 410 "Optional Factory Mounted Damper Actuator." Furnish integral face and bypass coils with factory mounted damper actuators.

2.15 DISCHARGE PLENUM SECTION
A. Discharge plenum section shall be furnished by the air handling unit manufacturer. The casing shall be constructed in accordance with Section 2.3. Inner wall shall be solid galvanized steel or aluminum. Provide access door and duct opening connections.

2.16 MARINE LIGHTS AND CONVENIENCE OUTLETS
A. Marine lights with 100-W vaporproof LED luminaires in all sections of the unit. Sections wider than 6 feet shall have multiple lights with maximum spacing of 6 feet. Marine lights shall be provided by the air handling unit manufacturer.
B. Duplex convenience outlets, 20 amp, 115V, GFCI protected, shall be provided by the air handling unit manufacturer.
C. Air handling unit manufacturer shall provide a single point of connection for 120V single phase power for all interior lights and convenience outlets.
D. Wiring of lights, switches and convenience outlets shall be provided by the air handling unit manufacturer and shall meet the requirements of Division 26.
E. Provide a single 2-hour timer switch to control all luminaires. Locate on outside of casing adjacent to the supply fan section access door.
F. Provide a duplex convenience outlet. Locate on outside of casing adjacent to the luminaire timer switch.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, housekeeping pads and other conditions affecting performance of the Work.
B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
C. Examine roughing-in for piping systems and electrical services to verify actual locations of connections before installation.
D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. Install central-station air-handling units level and plumb, in accordance with manufacturer's written instructions.
B. Equipment Mounting on Concrete Base: Install air-handling units on concrete bases. Secure units to anchor bolts installed in concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-Place Concrete." Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration Controls for HVAC."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. Install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Equipment Mounting without Concrete Base: Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration Controls for HVAC."

D. Suspended Units: Suspend units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration Controls for HVAC."

E. Arrange installation of units to provide access space around air-handling units for service and maintenance.

F. Floor-Mounted Units: Bottom of access doors to be a maximum of 14” above finished floor. Provide safety stair when bottom of access door is greater than 14” above finished floor.

G. Suspended-Units: Provide service platform the entire length of the unit on all sides containing access doors. Provide safety stair to floor to access platform.

H. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

I. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

J. All internally-mounted damper actuators, jackshafts and connections to damper sections are to be accessible through a minimum 24” x 24” access panel or door. When not possible, locate damper actuators and jackshafts external to the casing.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4 (DN 32), ASTM B 88, Type M (ASTM B 88M, Type C) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve, union or flange and shutoff valve at each coil return connection.
F. Steam and Condensate Piping: Comply with applicable requirements in Division 23 Section "Steam and Condensate Heating Piping." Install shutoff valve at steam supply connections, float and thermostatic trap, union or flange and shutoff valve at each coil return connection. Install valve and inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.

G. Refrigerant Piping: Comply with applicable requirements in Division 23 Section "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

H. Connect duct to air-handling units with flexible connections. Comply with requirements in Division 23 Section "Air Duct Accessories."

I. Electrical Connections: The following requirements apply:
   1. Electrical power wiring is specified in Division 26.
   2. Temperature control wiring and interlock wiring is specified in Division 23 Section "Instrumentation and Control for HVAC."

J. Provide 120 V power to feed AHU lights and receptacles. See Division 26 for all installation requirements.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform Tests and Inspections:
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and

C. Tests and Inspections:
   1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
   2. Charge refrigerant coils with refrigerant and test for leaks.
   3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Automatic-Roll-Filter Operational Test: Operate filters to demonstrate compliance with requirements. Test for leakage of unfiltered air while system is operating.
   5. HEPA-Filter Operational Test: Pressurize housing to a minimum of 3 inch wg (750 Pa) or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
   6. HEPA-Filter Operational Test: Pressurize housing to a minimum of 3-inch wg (750 Pa) or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter for air leaks according to ASME N510, pressure-decay method.
   7. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Leakage Test: Field test all air handling units.
   1. Leakage test shall be in accordance with SMACNA testing methods.
      a. Contractor shall provide test data after unit is fully installed confirming cabinet installation meets these requirements in accordance with SMACNA test method and as calculated as noted in ASHRAE Standard 111 and AHRI 1350. A minimal amount of ductwork may be connected to the air handling unit in order to seal off large openings. The ductwork must meet or exceed +/-4” static pressure.
b. If excessive air leakage is found locate leaks, repair in the area of the leak, seal, and retest.
c. Submit a signed report to the Owner's Construction Representative, indicating test apparatus used, results of the leakage test, and any remedial work required to bring air handling units into compliance with specified leakage rates.

E. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters in place, bearings lubricated (if applicable), condensate properly trapped, piping connections verified and leak-tested, belts aligned and tensioned, all shipping braces removed, bearing set screws torqued, and fan has been test run under observation.

B. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that zone dampers fully open and close for each zone.
7. Verify that face-and-bypass dampers provide full face flow.
8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
10. Verify that proper thermal-overload protection is installed for electric coils.
11. Install new, clean filters.
12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

C. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.6 ADJUSTING

A. Adjust water coil flow with control valves to full coil flow to indicated flow rate.

B. Adjust damper linkages for proper damper operation.

C. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
3.7 CLEANING

A. After startup service, clean air-handling units internally on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

B. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, clean filter housings and install new, clean filters.

C. Replace filters immediately prior to occupancy.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237313
SECTION 237413 - PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:
1. Direct-expansion cooling.
3. Hot-gas reheat.
4. Electric-heating coils.
5. Gas furnace.
6. Economizer outdoor- and return-air damper section.
7. Integral, space temperature controls.
8. Roof curbs.

1.3 DEFINITIONS
A. DDC: Direct-digital controls.
B. ECM: Electrically commutated motor.
C. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
D. Outdoor-Air Refrigerant Coil Fan: The outdoor-air refrigerant-coil fan in RTUs. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
E. RTU: Rooftop Unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.
F. Supply Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
G. Supply Air Refrigerant Coil: Refrigerant coil in the supply air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
H. VVT: Variable-air volume and temperature.

1.4 PERFORMANCE REQUIREMENTS
A. Delegated Design: Design RTU supports to comply with [wind] [and] [seismic] performance requirements, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
B. **[Seismic] [Wind]** Performance: RTUs shall withstand the effects of [seismic] [wind] forces determined according to the requirements of Division 23 Section "Vibration, Seismic, and Wind Controls for HVAC."

1.5 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Common Work Results for HVAC."

1.6 ACTION SUBMITTALS
A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories, including the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound power ratings.
   3. Certified coil performance ratings with system operating conditions indicated.
   4. Motor ratings and electrical characteristics plus motor and fan accessories.
   5. Materials gauges and finishes.
   6. Certified heat wheel performance data.
   7. Filter performance data.
   8. Damper performance data and descriptions of housings, linkages, and operators.

B. Certification Letter: Signed by manufacturers of applied rooftop packaged air conditioning units certifying that their products comply with specified requirements.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required installation and service clearances, method of field assembly, components, and location and size of each field connection.
   1. Wiring Diagrams: Power, signal, and control wiring, (differentiating between manufacturer-installed wiring and field-installed wiring).

1.7 INFORMATION SUBMITTALS
A. Field Quality Control Test Reports specified in Part 3 of this Section.

1.8 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.
   1. Special Warranty Information: Special warranty specified in this Section.

1.9 QUALITY ASSURANCE
A. ARI Compliance:
   1. Comply with the latest edition of ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
   2. Comply with the latest edition of ARI 270 for testing and rating sound performance for RTUs.

B. ASHRAE Compliance:
2. Comply with the latest edition of ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with ASHRAE/IESNA 90.1-2010 for minimum efficiency of heating and cooling.

C. NFPA Compliance: Comply with the latest editions of NFPA 90A and NFPA 90B.
E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
F. Motors shall conform to the latest applicable requirements of NEMA, IEEE, ANSI, and NEC standards.
G. Damper leakage rate shall be tested and certified in accordance with the Air Movement and Controls Association (AMCA) Standard 500.

1.10 DELIVERY, STORAGE AND HANDLING
A. Disassemble units as required for movement to the site location. Reassemble major units under direction of manufacturer's representative.
B. Lift and support unit with the manufacturer's designated lifting or supporting points.

1.11 SEQUENCING AND SCHEDULING
A. Coordinate the size and location of structural steel support members.
B. Coordinate the size and location of roof curbs.

1.12 WARRANTY
A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Compressors: Manufacturer's standard, but not less than \(<\text{Insert number}\) years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than \([\text{five (5)}] \ [\text{10}] \ [\text{15}] \ [\text{20}] \ <\text{Insert number}>\) years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than \([\text{three (3)}] \ <\text{Insert number}>\) years from date of Substantial Completion.
4. Warranty Period for Control Boards: Manufacturer's standard, but not less than \([\text{three (3)}] \ <\text{Insert number}>\) years from date of Substantial Completion.

1.13 EXTRA MATERIALS
A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fan Belts: \([\text{One set}] \ <\text{Insert number}>\) sets for each belt-driven fan.
2. Filters: Provide two spare sets of pre-filters and one spare set of final filters for each unit.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide [the product indicated on Drawings] <Insert manufacturer's name; product name or designation> or a comparable product by one of the following:

   1. AAON, Inc.
   2. Daikin Applied
   3. Trane; American Standard Companies, Inc.
   4. YORK, a Johnson Controls Company
   5. Johnson Controls, Inc.
   6. Carrier Corporation, a unit of United Technologies Corp.
   7. <Insert manufacturer's name>.

2.2 PACKAGED FACTORY ASSEMBLED UNITS

A. General:

   1. Provide and install packaged rooftop unit(s) including fans, compressors, coils, piping, electrical and DDC controls. Each system shall be factory assembled, piped, internally wired, and fully charged with refrigerant and ready to operate. The systems shall heat, cool, dehumidify and be of the constant volume or variable air volume type as so specified or scheduled on the plans. The units shall be constructed for outdoor installation and configured as shown on the plans.
   2. Factory packaged applied rooftop air conditioning system shall be the size indicated and shall contain the components indicated on drawings and described herein. Performance characteristics of all components are the minimum that will be acceptable.
   3. Units must be shipped in single piece or major assembled sections to facilitate ease of rigging and installation. Rigging and joining of sections shall be done at the job site. Field built units and their components will not be accepted. All units shall be inspected and tested at the manufacturer's plant before shipment is made to the jobsite.
   4. Entire unit shall be warranted by the manufacturer against defects in materials and workmanship, and for all parameters of the unit operation and performance, to include all components for a period of one year after first use by the owner.
   5. Manufacturer shall have a minimum of five (5) years of experience in building units of like kind.

B. Motor and Electrical Components: Refer to Division 23 Sections "Electrical Requirements for Mechanical Equipment and Motors."

C. Capacity, size, static pressure, coils, filters, accessories, limiting velocities, arrangement, etc., as shown on Drawings and referred to in appropriate Division 23 Sections.
2.3 CASING
A. The frame and unit base shall be made of 15 gauge (40 tons and below) or 13 gauge (45 tons and above) painted galvanized steel. The unit shall be provided with an integral structural base that extends the full length of the unit to facilitate curb or post and rail mounting. The unit base channel shall be equipped with lifting lugs for rigging.
B. Exterior surfaces shall be phosphatized and coated with baked-on Mist Gray enamel. Finished surface shall withstand a minimum 750 hour salt spray test in accordance with ASTM B117 standard for salt spray resistance. All sections of the unit shall be provided with full sized, double wall, hinged access doors, constructed of 17 gauge galvanized steel. Access doors shall utilize a three point (minimum) flush mounted single action lever, staggered engagement latching mechanism, which provides easy access to each cabinet section. Access doors shall be provided on both sides of the unit. Each door shall be equipped with a steel retainer rod to hold the door fully open.
C. Unit shall be completely insulated with 2 inch thick, foam or glass fiber insulation with an R-value of 6.0 (minimum) secured to all panels with adhesive. All interior surfaces of the unit shall include solid galvanized liners to form a double wall panel construction. Liners in the supply and return plenum areas of the unit shall be [solid] [perforated].
D. The unit shall incorporate a discharge plenum to provide additional sound attenuation.

2.4 FANS
A. Provide belt guards for belt driven fans, and safety screens where fan inlet or outlet is exposed to human contact.
B. Supply Fan Section:
   1. Supply fan shall be a centrifugal double width, double inlet, non-overloading, airfoil type. All fans shall be statically and dynamically balanced for quiet operation. The airfoil fan wheel shall be Class II type and fabricated from aluminum with the fan blades continuously welded to the back plate and end rim. Units shall have solid steel fan shafts mounted in heavy-duty, 200,000 hour relubricative ball bearings.
   2. Fan motors shall be heavy-duty, 1800 RPM, open drip-proof type with relubricative ball bearings. The motor shall have a variable pitch sheave and an adjustable base for proper alignment and belt tension adjustment. The entire fan assembly shall be completely isolated from the unit bulkhead with neoprene gasketing and mounted on double deflection spring isolators with thrust restraints.
C. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration, Seismic, and Wind Controls for HVAC" when fan-mounted frame and RTU mounted frame are anchored to building structure.
D. Fan Motor: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.5 COILS
A. Evaporator coils shall be multi-row interlaced circuiting and fabricated from 5/8 inch O.D. seamless copper tubing mechanically bonded to rippled and corrugated aluminum fins. Evaporator coils shall have rows and fins as scheduled.
B. Coils shall be factory leak tested at 315 PSIG under water. Each evaporator coil circuit shall be fed with an adjustable thermal expansion valve with an external equalizer.

C. A stainless steel positively sloped primary drain pan shall be provided beneath the cooling coil and extend beyond the leaving side of the coil and underneath the cooling coil connections. The drain pan shall be connected to a threaded drain connection extended through the unit base. Units shall be provided with a secondary stainless steel drain (extended under the coil distributor tubes, return bends and refrigeration specialties) connected to the primary drain pan.

RETURN FAN/ECONOMIZER SECTION

A. Return fans shall be centrifugal airfoil non-overloading type. All fans shall be statically and dynamically balanced for quiet operation.

B. The airfoil fan wheel shall be Class II type and fabricated from aluminum with the fan blades continuously welded to the back plate and end rim. Units shall have solid steel fan shafts mounted in heavy-duty, 200,000 hour relubricative ball bearings.

C. Fan motors shall be heavy duty, 1800 RPM, open drip-proof type with relubricative ball bearings. The motor shall have a variable pitch sheave and an adjustable base for proper alignment and belt tension adjustment. The entire fan assembly shall be completely isolated from the unit bulkhead with neoprene gasketing and mounted on double deflection spring isolators with thrust restraints.

D. Outside Air Section:
   1. The outside air/return air section shall be designed to form an economizer plenum. Outside air shall be introduced from both sides of the unit through a horizontal louvered intake complete with rain lip and bird screen. The floor of the outside air section shall be sloped to the outside of the unit for water drainage. The outside and return air dampers shall be sized to handle 100 percent of the supply air volume and arranged vertically to converge the return and outside air streams in a circular mixing pattern. Dampers shall be Ultra Seal low leak type with gasketed blade to blade contact and spring side seals. Damper blades shall be hollow core, airfoil type for extra rigidity. Air leakage through the damper section shall be less than two tenths of one percent leakage at 1.5 inches static pressure differential, or 6 CFM/Ft at 4 inch static pressure differential.
   2. A gravity relief type exhaust air damper shall be provided on all 0-100 percent outside air sections and located in the return air section to exhaust air out the back of the unit. Exhaust louvers and bird screen shall be provided to protect the relief damper. The exhaust dampers shall be lined with urethane gasketing on the contact edges.
   3. 0-100 percent outside air economizer control shall consist of outside, return air and exhaust air dampers, damper motor, and an adjustable enthalpy control mounted in the outside air stream. An enthalpy control shall be provided to sense the dry bulb temperature and relative humidity of the outside air and compare it to the building return air to optimize the choice of outdoor air or return air for economizer cooling mode. The damper motor shall be of the modulating spring return type.
2.7 VARIABLE AIR VOLUME CONTROL

A. An electronic variable frequency drive shall be provided for the supply and return air fans. Each drive shall be factory installed in a designated access section, downstream of the filters and upstream of the cooling coil, in a manner that the drive(s) are directly cooled by the filtered, mixed air stream. Drives shall meet UL Standard 95-5V and the variable frequency drive manufacturer shall have specifically approved them for plenum duty application. The completed unit assembly shall be listed by a recognized safety agency, such as ETL. Drives are to be accessible through a hinged door assembly complete with a single handle latch mechanism. Mounting arrangements that expose drives to high temperature, unfiltered ambient air are not acceptable. The unit manufacturer shall install all power and control wiring. The supply and return fan drive outputs shall be independently controlled in order to provide the control needed to maintain building pressure control. Refer to Division 26 Section ____________ for additional variable speed drive requirements.

2.8 CONDENSING SECTION

A. (75 Tons and Above): Compressors shall be high efficiency, heavy-duty, Copeland Discus reciprocating, semi-hermetic type with reversible, positive displacement oil pump, suction and discharge line service valves, crankcase heater, high efficiency blocked suction unloading, and 3 leg inherent motor overload protection. Compressors shall be isolated on spring isolators with braided type vibration eliminators in the piping to decrease vibration and noise transmission.

B. The unit shall have two independent refrigeration circuits. Each refrigeration circuit shall include a liquid line solenoid valve, low pressure control, liquid moisture indicator/sight-glass, replaceable core filter drier, thermal expansion valve, liquid line shutoff valve with charging port, manual reset high pressure safety switch, high pressure relief valve and pump down switch. The thermal expansion valve shall be capable of modulation for 100 percent to 25 percent of its rated capacity. Compressor capacity reduction shall be accomplished with cylinder unloading. A minimum of six stages shall be provided. Hot gas bypass control shall be factory installed on both refrigerant circuits. Hot gas bypass control shall include a modulating hot gas bypass control valve, integral solenoid valve, all associated piping, and be automatically operated by the units microprocessor control.

C. (70 Tons and Below): Unit shall have multiple, heavy-duty Copeland scroll compressors. Each compressor shall be complete with gauge ports, crankcase heater, sight-glass, anti-slug protection, motor overload protection and a time delay to prevent short cycling and simultaneous starting of compressors following a power failure. Compressors shall be isolated with resilient rubber isolators to decrease noise transmission.

D. The unit shall have two independent refrigeration circuits. Each circuit shall be complete with a liquid line solenoid valve, low pressure control, filter-drier, liquid moisture indicator/sight-glass, thermal expansion valve, liquid line shutoff valve with charging port, discharge line shutoff valve, a manual reset high pressure safety switch, high pressure relief device and pump down switch. The thermal expansion valve shall be capable of modulation from 100 percent to 25 percent of its rated capacity. A minimum of three stages shall be provided. Hot gas bypass control shall be factory installed on both refrigerant circuits. Hot gas bypass control shall include a modulating hot gas bypass control valve, integral solenoid valve, all associated piping, and be automatically operated by the units microprocessor control.
E. The condensing unit section shall be open on the sides and bottom to assure complete access and airflow through the coils. Condenser coils shall be multi-row type fabricated from 3/8 inch O.D. high efficiency rifled copper tubing mechanically bonded to aluminum fins (copper where indicated on the schedule). Each refrigerant circuit shall include a sub-cooler circuit to provide 15 degrees F of sub liquid sub-cooling. Each condenser shall be factory leak tested under water. Each circuit shall be dehydrated and factory charged with refrigerant and oil.

F. Provide condenser coil guards, constructed of cross wire welded steel, PVC coated, where indicated on the schedule. Mount guards to each side of the condensing section to provide protection to the condenser coil.

G. Condenser fans shall be direct drive, propeller type designed for, low tip speed and vertical air discharge. Fan blades shall be constructed of steel and riveted to a steel center hub.

H. Condenser fan motors shall be heavy-duty, inherently protected three-phase non-reversing type with permanently lubricated ball bearing and integral rain shield.

I. Units shall have at least one condenser fan controlled to maintain positive head pressure. An ambient thermostat shall prevent the refrigeration system from operating below 45 degrees F. Condenser fan speed control shall be added to the last fan off on each refrigeration circuit to provide cooling operation to ambient temperatures down to 0 degrees F.

J. Refrigeration Specialties:
   1. Refrigerant Charge: [R-22] [R-407C] [R-410A] <Insert type>.
   2. Expansion valve with replaceable thermostatic element.
   3. Refrigerant filter/dryer.
   5. Automatic-reset low-pressure safety switch.
   8. Brass service valves installed in compressor suction and liquid lines.
   9. Low-ambient kit high-pressure sensor.
  11. Hot-gas bypass solenoid valve with a replaceable magnetic coil.
  12. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

2.9 ELECTRIC REHEAT

A. Electric heating coils shall be located in the reheat position and be constructed with low watt density nickel chromium elements. Safety controls shall include automatic reset high limit control for each heater element in the discharge air stream of each heater bank, and line break protection in each heater circuit. Heating element branch circuits shall be individually fused to a maximum of 48 amps to meet NEC requirements.

B. A microprocessor-based DDC control system with full magnetic line break contactors shall provide multiple stages of control. The electric heating section shall contain a single point electrical connection with a factory mounted non-fused disconnect switch to provide power to the unit as well as the electric heat section.
2.10 GAS HEAT
   A. A natural gas fired furnace shall be installed in the unit heat section. The heat exchanger shall include a type 430 stainless steel cylindrical primary combustion chamber, a type 430 stainless steel header, type 430 stainless steel secondary tubes, and type 430 stainless steel turbulators. The heat exchanger shall have a condensate drain. Clean out of the primary heat exchanger and secondary tubes shall be accomplished without removing casing panels or passing soot through the supply air passages. The furnace section shall be positioned downstream of the supply air fan.
   B. The furnace will be supplied with a modulating forced draft burner capable of continuous modulation between 5 percent and 100 percent of rated capacity, without steps. The burner shall operate efficiently at all firing rates. The burner shall have proven open damper low-high-low pre-purge cycle, and proven low fire start. The combustion air control damper shall be in the closed position during the off cycle to reduce losses. The burner shall be rated for operation and full modulation capability at inlet gas pressures down to 7.0 in. W.C. The shutoff cock and test cock shall be fully ported ball valves.
   C. The burner shall be specifically designed to burn natural gas and shall include a microprocessor based flame safeguard control, combustion air proving switch, pre-purge timer and spark ignition. The gas train shall include redundant gas valves, shutoff cock, pilot gas valve, pilot pressure regulator, and pilot cock. The gas train shall be FM or IRI rated.
   D. The gas burner shall be controlled by the factory installed main unit control system.

2.11 STATIC MIXER (AIR BLENDER)
   A. A static air mixing device shall be factory installed between the outside/return air section and the filter section. The static air mixer shall be installed with proper upstream and downstream distances. The mixing device shall perform at face velocities from 500 fpm through 2500 fpm with no loss in mixing performance. The mixing device shall provide mixing and distribution of the outside and return air streams to minimize the threat of coil freeze-up during operation and to improve temperature control.

2.12 SOUND ATTENUATOR
   A. A section shall be provided by the air handling unit manufacturer as an integral part of the unit to attenuate fan noise. Refer to Division 23 Section "Sound Attenuators" for sound attenuator requirements. Hinged access doors shall be provided on both sides of the section and shall have the same construction as the rest of the unit.

2.13 DISCHARGE PLENUM
   A. A supply air discharge plenum shall be provided. A combination burglar bar/safety grate shall be provided in the bottom return and supply air openings. Burglar bar/safety grate shall be made of 3/4 inch diameter ground and polished steel shaft welded to a galvanized steel frame.

2.14 AIR FILTRATION
   A. The filter section shall be supplied complete with galvanized steel filter racks as an integral part of the unit. Filters shall be accessible from both sides of the unit. Refer to Division 23 Section "Particulate Air Filtration" for filter requirements.
   B. Draw through filter section shall be provided with 2 inch thick MERV 7 pleated pre-filters mounted in a galvanized steel filter frame.
C. Blow through final filter section shall be provided with 12 inches deep MERV 15, UL Std. 900, Class 1, cartridge filters. For units with gas or electric heat, high temperature cartridge filters rated for 500 degrees F shall be used. Cartridge filters shall consist of filter media permanently attached to a metal frame and shall slide into a gasketed, extruded aluminum rack contained within the unit. The filter rack shall have secondary gasketed, hinged end panels to insure proper sealing. Filters shall be accessible from both sides of the filter section.

2.15 ELECTRICAL

A. Each unit shall be wired and tested at the factory before shipment. Wiring shall comply with NEC requirements and shall conform with all applicable UL standards. All electrical components shall be labeled according to the electrical diagram and be UL recognized where applicable. Each unit shall have a 115 volt control circuit transformer, 115 volt receptacle with separate electrical connection.

B. The supply air and return air fan, compressor and condenser fan motor branch circuits shall be individually fused. Contactors and inherent thermal overload protection. Shall be furnished for each compressor and condenser fan motor. The supply and return air fan motors shall have contactors and external overload protection. The unit shall include a weatherproof main control panel and mounted within a weatherproof construction with a dead front cover over main power circuit control. A single point through the door non-fused disconnect shall be provided for the main power connection and a terminal board shall be provided for low voltage control wiring. Knockouts shall be provided in the he bottom of the main control panels for field wiring entrance. A separate key locked control panel shall house all controls for the condensing section.

C. Phase failure and under voltage protection on three-phase motors shall be provided to prevent damage from single phasing, phase reversal, and low voltage conditions.

D. Factory mounted smoke detectors shall be factory installed in the supply and return air openings. Smoke detectors to be ionization type, which responds to invisible products of combustion without requiring the sensing of heat, flame or visible smoke. Upon sensing smoke, the unit shall provide a control output for use by building management system.

2.16 CONTROLS

A. Control equipment and sequence of operation are specified in Division 23 Section "Instrumentation and Control for HVAC."

B. The applied rooftop packaged air conditioning systems shall be provided with DDC controls to control all unit functions. The control system shall be suitable to control constant volume or variable air volume applications. The controller shall be factory installed and mounted in the main control panel of the unit. The unit shall have a keypad/display module to allow adjustment and display of control functions. The display window shall be a 32 character monitor providing the operator with full description and output of pertinent data. The unit controller shall be capable of being used as a stand-alone control, or as part of networked control system involving multiple units.

1. The unit shall be equipped with a complete microprocessor control system. The system shall consist of temperature and pressure (thermistor and transducer) sensors, input/output board, power supply board, main processor board with display and keypad, and all staging boards. Boards shall be individually replaceable for ease of service. All microprocessors, boards, and sensors shall be factory mounted, wired, and tested.
2. The microprocessor shall be a standalone DDC controller not dependent on communications with an on-site PC or the Network Master Panel. The microprocessor shall be equipped with LEDs indicating all hardware, software, and interconnecting wiring are in proper operating condition.

3. The input/output boards shall be optically isolated to prevent transients or wrong voltages from entering the board circuits. Direct wired, fuses, or MOVs are not acceptable means of wiring to the I/O boards. Each digital input and digital output shall be equipped with an LED for ease of service. All field wiring shall be terminated at a separate, clearly marked terminal strip. Direct wiring to the I/O boards is not acceptable.

4. The microprocessor memory shall be non-volatile EEPROM type requiring no battery backup to maintain all data, even during an extended shutdown or power failure.

5. The main microprocessor shall support an RS-232 direct connection to a product service tool or a modem. A [BACnet IP] [BACnet MSTP] [LonWorks] communications port shall be provided for direct communication into the BAS network.

6. Should the rooftop unit ever lose either direct connect or network communications, the microprocessor shall maintain existing set points. Defaulting to a pre-defined condition or setpoint shall not be acceptable.

7. The microprocessor shall have a built-in time schedule. The schedule shall be programmable from the unit keypad interface. The schedule shall be maintained in nonvolatile memory to insure that it is not lost during a power failure. There shall be one start/stop per day and a separate holiday schedule. The controller shall accept up to sixteen holidays each with up to a five (5) day duration. Each unit shall also have the ability to accept a time schedule via BAS network communication.

8. Provide night setback space temperature control sensor, and field wiring to the unit DDC controller, where indicated on the plans.

9. Each packaged rooftop unit shall incorporate an optimum stop sequence. The unit shall be programmable with fixed heating and cooling factors or have the ability to adjust the start/stop times automatically based on the historical performance of the unit.

C. Space sensors shall be available in several combinations with selectable features. All sensors will be optional in use with the RPS units. Options include:

   1. 3K thermistor for temperature indication and LED annunciation for unit status and alarms.
   2. All of 1. above and tenant override.
   3. All of 2. above and setpoint adjustment.

D. The keypad display character format shall be 20 characters x 4 lines. The character font shall be 5 x 8 dot matrix. The display shall be supertwist liquid crystal display (LCD) with black characters on yellow background providing high visibility. The display form shall be in plain English coded formats.

E. The keypad shall be equipped with 8 individual touch-sensitive membrane key switches. All control settings shall be password protected from changes by unauthorized personnel.

F. The user interaction with the display section of the interface shall provide the following:

   1. Return Air Temperature.
   2. Supply Air Temperature.
   3. Outdoor Air Temperature #2 (optional).
   4. Space Air Temperature.
   7. Outdoor enthalpy high/low.
   8. Pre-filter pressure.
10. Airflow verification.
11. Supply fan status.
12. Return fan status.
14. Duct static pressure.
15. Duct static pressure.
17. Heating status.
18. Control temperature changeover.
20. VAV output status.
22. Unit status.
23. Unit mode of operation.
24. Time schedules.
25. Current alarm with time and date.
26. Previous alarm with time and date.
27. Sixteen alarms in order of occurrence.

G. The user interaction with the keypad section of the interface shall provide the following set points as minimum:

1. Control Modes:
   b. Auto.
   c. Occupied only.
   d. Occupied cool only.
   e. Occupied heat only.
   f. Occupied fan only.
   g. Calibrate.

2. Control Temperature (Changeover):
   a. Return air temperature.
   b. Space temperature.

3. Cooling setpoint with differential.
5. Cooling supply setpoint.
6. Cooling Supply Reset Options:
   a. Return air temperature.
   b. Outdoor air temperature.
   c. Space temperature.
   d. No reset.
   e. Network signal (other BAS or EMS).

7. Reset target temperatures.
8. Interstage timers on compressors (min. 4 minutes).
9. Temperature High Limits:
   a. High supply air temperature setpoint.
   b. Low supply air temperature setpoint.
   c. High return air temperature setpoint.

10. Ambient lockout setpoint on compressors.
11. Auto Lead-Lag on Compressors:
   a. Auto.
   b. Circuit 1 lead.
   c. Circuit 2 lead.

12. Night setback space temperature setpoint.
13. Duct static pressure setpoint.
14. Minimum Outdoor Airflow:
   a. Setpoint as a percent of CFM capacity.

15. Enthalpy selection.
16. Dry bulb selection option.
17. Dirty Filter Set Points:
   a. Pre-filters.
   b. Final filters.

18. Current time and date.
19. Tenant override setpoint.
20. Occupied/Unoccupied time schedules.
21. Holiday dates and duration.
22. Service Mode:
   a. Timers normal (all time delays active).
   b. Timers fast (all time delays).
   c. Mode normal (unit on).
   d. Mode shutdown (unit off).

2.17 ACCESSORIES
A. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
B. Coil guards of painted, galvanized-steel wire.
C. Hail guards of galvanized steel, painted to match casing.

2.18 ROOF CURBS
A. Roof curbs with vibration isolators [and restraints] are specified in Division 23 Section "Vibration, Seismic, and Wind Controls for HVAC."
B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
   1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
      a. Materials: ASTM C 1071, Type I or II.
      b. Thickness: [1 inch (25 mm)] [1-1/2 inches (38 mm)] [2 inches (50 mm)] <Insert thickness>.
   2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
      a. Liner Adhesive: Comply with ASTM C 916, Type I.
b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.

c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.

d. Liner Adhesive: Comply with ASTM C 916, Type I.

C. Curb Height: [14 inches (355 mm)] [24 inches (610 mm)] [36 inches (910 mm)] <Insert height>.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, housekeeping pads, and other conditions affecting performance of RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping, electric and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Manufacturer shall provide field supervision of assembly, start-up and checkout of assembled system.

B. Install applied rooftop packaged air conditioning systems level and plumb, in accordance with manufacturer's instructions.
   1. Support floor mounted indoor units on concrete equipment bases using neoprene pads or housed spring isolators as scheduled. Secure units to anchor bolts installed in concrete equipment base for seismic support.
   2. Support roof mounted units on structural dunnage. Secure units with anchor bolts as required for [seismic] [wind] support.

C. Arrange installation of units to provide access space around rooftop units for service and maintenance.

D. Coordinate control sensor installation with Controls Contractor.

E. Install restraints according to manufacturer's written instructions. [Wind and seismically restrained vibration isolation roof-curb rails are specified in Division 23 Section "Vibration, Seismic, and Wind Controls for HVAC." ]

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 sections. The Drawings indicate the general arrangement of piping, valves, fittings, and specialties. The following are specific connection requirements:
   1. Arrange piping installations adjacent to units to allow unit servicing and maintenance.
   2. Connection piping to applied rooftop units with flexible connectors.
3. Connection condensate drain pans using 1-1/4 inch, Type M copper tubing. Extend to the nearest floor drain or to roof. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

4. Gas Piping: Comply with applicable requirements in Division 23 Section ["Facility Natural-Gas Piping"] ["Facility Liquefied-Petroleum Gas Piping"]. Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

B. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
   1. Install ducts to termination at top of roof curb.
   2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
   3. Connect supply ducts to RTUs with flexible duct connectors specified in Division 23 Section "Air Duct Accessories."
   4. Install return air duct continuously through roof structure.
   5. Install normal weight, 3000 psi (20.7 MPa), compressive strength (28 day) concrete mix inside roof curb, [4 inches (100 mm)] <Insert thickness> thick. Concrete, formwork, and reinforcement are specified in Division 03.

C. Electrical Connections: The following requirements apply:
   1. Electrical power wiring is specified in Division 26.
   2. Temperature control wiring and interlock wiring is specified in Division 23 Section "Automatic Temperature Control Systems."
   3. Grounding: Connect unit and components to ground in accordance with the National Electrical Code.

3.4 FIELD QUALITY CONTROL
A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
B. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. Report results in writing.
C. Tests and Inspections:
   1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
D. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING, CLEANING AND PROTECTING
A. Adjust water coil flow, with control valves to full coil flow, to indicated gpm.
B. Adjust damper linkages for proper damper operation.
C. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet and coils entering air face.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
B. Install concrete if equipped with inertia base.
C. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork and electrical are complete. Verify proper thermal overload protection is installed in motors, starter, and disconnects.
D. Perform cleaning and adjusting specified in this Section.
E. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts and install belt guards.
F. Lubricate bearings, pulleys, belts and other moving parts with factory recommended lubricants.
G. Set heat wheel or heat pipe into operation.
H. Set outside-air and return air mixing dampers to minimum outside-air setting.
I. Comb coil fins for parallel orientation.
J. Install clean filters.
K. Verify manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in the full-open position.
L. Disable automatic temperature control operators.
M. Starting procedures for applied rooftop systems:
   1. Energize motor, verify proper operation of motor, drive system and fan wheel. Adjust fan to indicated RPM.
      a. Replace fan and motor pulleys and belts as required to achieve design conditions.
   2. Measure and record motor electrical values for voltage and amperage.
   3. Vacuum the heat exchanger. Clean after all necessary tests have been carried out and before system is turned over to Owner.
N. Shut unit down and reconnect automatic temperature control operators.
O. Refer to Division 23 Section "Testing, Adjusting and Balancing for HVAC" for procedures for rooftop system testing, adjusting, and balancing.

3.7 POST OCCUPANCY ADJUSTMENT

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to <Insert number> visits to site during other-than-normal occupancy hours for this purpose.
B. After completing system installation and testing, adjusting, and balancing RTU and air distribution systems, clean filter housings, and install new filters.
3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to provide minimum eight (8) hour training to Owner’s maintenance personnel to adjust, operate, and maintain RTUs. Refer to Division 01 Section “Demonstration and Training.”

END OF SECTION 237413
SECTION 238119 - SELF-CONTAINED AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY
   A. Section includes packaged, air and water-cooled air-conditioning units with refrigerant compressors and controls intended for indoor installations.

1.2 SUBMITTALS
   A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories.
   B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
      1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
      2. Wiring Diagrams: For power, signal, and control wiring.
   C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For self-contained air conditioners to include in emergency, operation, and maintenance manuals.
      1. Special Warranty Information: Sample of special warranty.

1.5 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   B. ARI Compliance:
   C. ASHRAE Compliance:
      1. Fabricate and label refrigeration system to comply with the latest edition of ASHRAE 15, "Safety Standard for Refrigeration Systems."
1.6 COORDINATION
   A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

1.7 WARRANTY
   A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of self-contained air conditioners that fail in materials or workmanship within specified warranty period.
      1. Warranty Period:
         a. For Compressor: Five year from date of Substantial Completion.
         b. For Parts: One year from date of Substantial Completion.
         c. For Labor: One year from date of Substantial Completion.

1.8 EXTRA MATERIALS
   A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      1. Filters: One set of filters for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. McQuay International.
      2. Trane, Inc.
      3. Johnson Controls - York

2.2 PACKAGED UNITS
   A. Description: Factory assembled, wired, and tested; and fully charged with refrigerant and oil.
   B. Configuration: Provide unit configuration as indicated on the Plans. If not indicated utilize one of the following:
      1. Horizontal, ceiling mounted.
      2. Vertical, floor mounted.
   C. Disconnect Switch: Factory mounted on cabinet.

2.3 CABINET
   A. Frame and Panels: Structural-steel frame with galvanized-steel panels and access doors or panels.
      2. Interior-Surface Finish: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.
B. Insulation: 1-inch- (25-mm-) thick, glass-fiber duct liner complying with ASTM C 1091 and having a microbial coating on cabinet interior and control panel. 1/2-inch- (13-mm-) thick liner is acceptable for units smaller than 15 tons (50 kW).

C. Corrosion-Resistant Treatment: Phenolic coating on unit interior and exterior.

2.4 SUPPLY-AIR FAN

A. Fan Material: Galvanized steel.

B. Configuration: Double-width, double-inlet, forward curved or airfoil centrifugal fan; statically and dynamically balanced. Vertical or horizontal discharge with flexible discharge collar.

C. Drive: [Belt, with fan mounted on permanently lubricated bearings] [Direct, with fan and motor resiliently mounted].

D. Fan Sheaves: Variable pitch, dynamically balanced, bored to fit shafts, and keyed for initial startup.

E. Motor Sheave: Variable and adjustable pitch, dynamically balanced, and selected to achieve specified rpm when set at midposition.

F. Belt Rating: As recommended by manufacturer or a minimum of one and one-half times nameplate rating of motor.

G. Bearings: Grease lubricated with grease lines extended to exterior of unit with L-50 life at 200,000 hours.

H. Variable Air Volume: Variable-frequency motor controller.

I. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Special Motor Features: Premium efficiency, as defined in Division 23 Section "Common Motor Requirements for HVAC Equipment."

J. Isolation: Mount fan and motor on common subbase and mount assembly on spring isolators with minimum static deflection of 1 inch.

K. Outdoor-Air-Intake Accessories:

1. Air-Side Economizer: Damper assembly allowing induction of up to 100 percent outdoor air to maintain a selected mixed-air temperature; and exhaust damper and spring-return, low-voltage, modulating damper motor with minimum position adjustment.

2.5 REFRIGERATION SYSTEM

A. Compressor: Scroll type, hermetically sealed, 3600 rpm maximum, and resiliently mounted with positive lubrication and internal motor protection.

B. Refrigerant Coils (Indoor and Outdoor for Air-Cooled Units): Seamless copper tubes expanded into aluminum fins.


2. Refrigerant Circuits: A separate circuit for each compressor, with externally equalized thermal-expansion valve with adjustable superheat, filter dryer, sight glass, high-pressure relief valve, and charging valves.

4. Refrigerant: R-407C or R-410A.

5. Expansion valve with replaceable thermostatic element.

6. Refrigerant dryer.

7. High-pressure switch.

8. Low-pressure switch.

9. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.

10. Low ambient temperature switch.

11. Brass service valves installed in discharge and liquid lines.

C. Water-Cooled Condenser:

1. Description: Factory assembled and tested; tube in tube coaxial type with water-regulating valve.

2. Tubing: Copper or Cupro-nickel inner tube; refrigerant and water-side leak tested to 400 psig (2760 kPa) underwater.

D. Water-Side Economizer Section:

1. Description: Factory assembled and tested; consisting of water coil, modulating valves, controls, piping with cleanouts, and access panels.

2. Water Coil: Four rows, copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and copper headers; leak tested to 300 psig (2070 kPa) underwater; and having a two-position control valve.

2.6 HEATING COIL

A. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; and having a two-position control valve.

2.7 CONTROLS

A. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

B. Control Package: Factory wired, including contactor, high- and low-pressure cutouts, internal-winding thermostat for compressor, control-circuit transformer, and noncycling reset relay.

C. Time-Delay Relay: Five-minute delay to prevent compressor cycling.

D. Adjustable Thermostat: Remote to control the following:

1. Supply fan.

2. Compressor.

3. Condenser.

4. Hot-water coil valve.


F. Fan Control Switch: Auto-on.

G. Time Clock: Cycle unit on and off.
H. Microprocessor Control Panel: Controls unit functions as standalone or network operation, including refrigeration and safety controls, with unit-mounted display, and the following:

1. Supply fan.
2. Supply-fan motor speed.
3. Compressors.
5. Cooling tower pump.
7. Multistep, electric heater.
8. Time-of-day control to cycle unit on and off.
10. Economizer control.
11. Panel-mounted control switch to operate unit in remote or local control mode or to stop or reset.
12. Panel-mounted indication of the following:
   a. Operating status.
   b. System diagnostics and safety alarms.
   c. Supply-air temperature set point.
   d. Zone heating-temperature set point.
   e. Supply-air pressure set point.
   f. Economizer minimum position set point.
   g. Supply-air-pressure, high-limit set point.
   h. Monitor constant and variable motor loads.
   i. Monitor variable-frequency drive operation.
   j. Monitor economizer cycle.
   k. Monitor cooling load.
   l. Monitor air distribution static pressure and ventilation air volumes.

2.8 CAPACITIES AND CHARACTERISTICS

A. Refer to Drawings.

B. Filters:

1. Prefilters:
   a. Type: Pleated disposable panel.
   b. MERV: 7.
   c. Thickness or Depth: 2 inches.
   d. Maximum or Rated Face Velocity: 500 fpm.
   e. Initial Resistance: 0.20 inch w.g.
   f. Recommended Final Resistance: 1 inch wg.
   g. Access Location: Front.

C. Accessories:

3. Air-side economizer.
5. Hot-gas bypass.
6. Air Pressure Switch: Indicates when differential pressure exceeds set point representing dirty filters.
PART 3 - EXECUTION

3.1 INSTALLATION
A. Install units level and plumb.
B. Anchor units to structure.

3.2 CONNECTIONS
A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
   1. Water Coil Connections: Comply with requirements in Division 23 Section "Hydronic Piping." Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
   2. Water-Cooled Condenser Connections: Comply with requirements in Division 23 Section "Hydronic Piping." Connect to supply and return with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
C. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply[ and return] ducts to self-contained air conditioners with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL
A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
B. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
C. Tests and Inspections:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation, and inspect for refrigerant leaks.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
D. Units will be considered defective if they do not pass tests and inspections.
E. Prepare test and inspection reports.

3.4 STARTUP SERVICE
A. Perform startup service.

3.5 DEMONSTRATION
A. Train Owner's maintenance personnel to adjust, operate, and maintain units.
END OF SECTION 238119
SECTION 238123 – COMPUTER ROOM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following types of computer room air-conditioning units:
   1. Floor-mounting units 6 tons (21 kW) and larger.
   2. Floor-mounting units 5 tons (18 kW) and smaller.
   3. Ceiling-mounting units.

1.2 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS
A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.4 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For computer room air-conditioning units to include in emergency, operation, and maintenance manuals.
   1. Special Warranty Information: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
B. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
D. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE/IESNA 90.1-2013, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
E. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 01.
1.6 COORDINATION

A. Coordinate layout and installation of computer room air-conditioning units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Coordinate installation of computer room air-conditioning units with computer room access flooring installer.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of computer room air-conditioning units that fail in materials or workmanship within specified warranty period.

B. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of start up Substantial Completion.

C. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.

D. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: One set for each belt-drive fan.
2. Filters: One set of filters for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 FLOOR-MOUNTING UNITS 6 TONS (21 KW) AND LARGER

A. Manufacturers:

1. Data Aire, Inc.
2. Liebert Corporation.
3. Stulz Investment Corp. of America.

B. Description and Assembly: Packaged, factory assembled, prewired, and prepiped; consisting of cabinet, fans, filters, humidifier, and controls.

1. Assembly: Upflow or Downflow air delivery, in draw-through or blow-through configuration.
C.

Cabinet and Frame: Welded steel, suitably braced for rigidity, supporting compressors and other mechanical equipment and fittings. All frame and internal components shall be coated using an autophoretic process to protect against corrosion. With floor stand with adjustable legs and vibration isolation pads.

1. Doors and Access Panels: Galvanized steel with polyurethane gaskets, hinges, and concealed fastening devices. All panels shall have captive 1/4 turn fasteners and shall be removable for service access.
2. Insulation: Thermally and acoustically insulate cabinet interior with 1-inch- (25-mm-) thick duct liner.
3. Finish of Exterior Surfaces: Baked-on, textured vinyl enamel, color as selected from manufacturer's standard colors.
4. Floor Stand: For downflow units, provide a welded tubular steel floor stand, height in accordance with raised floor elevation.

D.

Evaporator Fan:

Provide centrifugal type fan, double width, double inlet, statically and dynamically balanced as a completed assembly to a maximum vibration level of two mils in any plane. The shaft shall be heavy duty steel with self-aligning ball bearings with a minimum life span of 100,000 hours. The fan motor shall be mounted on an adjustable slide base. The drive package shall be variable speed. The fan shall be located to draw air over the coil to ensure even air distribution and maximum coil performance. Double inlet, forward curved, centrifugal, and statically and dynamically balanced.

1. Drive: Direct.
2. Motor: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."


E.

Compressors:

Provide compressors located in a separate compartment so they may be serviced during operation of the equipment Hermetic scroll; with oil strainer, internal motor overload protection, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.

1. Refrigeration Circuits: Two, each with hot-gas mufflers, thermal-expansion valve with external equalizer, liquid-line solenoid valve, liquid-line filter-dryer, sight glass with moisture indicator, service shutoff valves, charging valves, accumulator sized for liquid seal under light load, and charge of refrigerant.
2. Refrigerant: R-407C or R-410A.

F.

Evaporator Coil: Alternate-row or split-face-circuit, direct-expansion coil of seamless copper tubes expanded into aluminum fins. Mount coil assembly over stainless-steel drain pan having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.

G.

Capacity Control Valves:

Provide capacity control valves that are controlled by the microprocessor. The valves shall permit multi-step capacity in both the cooling and dehumidification modes.

H.

Expansion Valves:

Provide expansion valves of the balanced-port, high-capacity type. Valves shall maintain a minimum differential working pressure in conjunction with the head pressure control of the condenser.

I.

Water-Cooled Condenser: Shell-and-tube type fabricated and labeled according to ASME Boiler and Pressure Vessel Code, Section VIII, or Coaxial tube-in-tube type with liquid-line stop valve and head-pressure-actuated, two-way, water-regulating valve. Terminate water connections outside cabinet.
J. Air Cooled Condenser: Provide slow speed, multiple direct drive propeller fan air cooled condenser. The condenser shall be constructed of aluminum and contain a copper tube, aluminum fin coil with an integral electric control panel. Winter control shall be fan speed control. The control system shall be complete with transducers, thermostats and electrical control circuit, factory prewired and tested in an integral control panel. The transducer shall automatically sense the head pressure of the compressor and control the variable speed fan on the air cooled condenser to properly maintain the head pressure. The fan speed control system shall provide positive start-up and operation in ambient temperature as low as -20 degrees F. Provide a solid state winter start kit as an integral feature of the electronic control panel. Provide a liquid line solenoid valve for pump down control.

K. Winter Control System: Provide a winter control system for the air cooled condenser. The system shall allow start-up and positive head pressure control with ambient temperatures as low as -30 degrees F. The control system shall include, for each circuit, insulated receivers, pressure relief valves, head pressure three-way control valves and rotoloc valves for isolating the refrigerant charge. The receivers shall be factory insulated and mounted ready for the field connection to the air cooled condenser.

L. Water Cooled Condenser: Provide for each circuit a cleanable, shell and tube, counterflow type of condenser with removable heads. Condensers shall be ASME stamped for a maximum refrigerant pressure of 400 psi at 300 degrees F. Provide for each circuit a prepiped head pressure activated regulating valve.

M. Glycol Cooled Condenser: Provide for each circuit a cleanable, shell and tube, counterflow type of condenser with removable heads. Condensers shall be ASME stamped for a maximum refrigerant pressure of 400 psi at 300 degrees F. Provide for each circuit a prepiped head pressure activated regulating valve and parallel bypass valve. Provide a low profile, slow speed, multiple direct drive propeller fan type drycooler. The drycooler shall be constructed of aluminum and contain a copper tube aluminum fin coil with an integral electric control panel and disconnect switch.

N. Chilled-Water Coil: Seamless copper tubes expanded into aluminum fins with modulating control valve. Mount coil assembly over stainless-steel drain pan having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.

O. Glycol Cooling Coil: Seamless copper tubes expanded into aluminum fins with three-way control valve.

P. Glycol Free Cooling: Provide copper tube, aluminum fin glycol free cooling coil located in the return air before the evaporator coil. Provide a fully proportional 3-way control valve. This motorized control valve shall control the amount of flow to the glycol cooling coil and maintain constant temperature and relative humidity. Provide each condenser with a prepiped head pressure activated three-way regulating valve.

Q. Electric-Resistance Heating Coil: Enclosed finned-tube electric elements arranged for minimum of three stages, with primary and secondary thermal switches, manual-reset overload protection, and branch-circuit overcurrent protection.

R. Electric Reheat: Provide electric reheat coils of low watt density, stainless steel, fin tubular construction, protected by thermal safety switches.

S. Refrigerant Reheat Coil: Hot-gas refrigerant coil of seamless copper tubes expanded into aluminum fins with three-way solenoid valve on first-stage refrigerant circuit.

T. Hot-Water Reheat Coil: Seamless copper tubes expanded into aluminum fins with two-way modulating control valve and strainer.
U. Filter: Pleated, lofted, nonwoven, reinforced cotton fabric; supported and bonded to welded-wire grid; enclosed in cardboard frame.
   1. Nominal Thickness: 2 inches (50 mm) 4 inches (100 mm).
   2. Dust-Spot Efficiency: 30 percent.
   3. Initial Resistance at 500-FPM (2.54-m/s) Face Velocity: 0.30-inch wg (75 Pa).

V. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepped and using condensate water from cooling coils with stainless-steel or brass float-valve mechanism; located in bypass airstream; with flush-cycle timer and solenoid drain valve.

W. Auto Flush System: Provide auto flush system which shall automatically flush deposits from the humidifier pan. The system shall be field adjustable to change the cycle time to suit local water conditions.

X. Remote Glycol Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, multiple direct-drive propeller fans with fan guards, and single-phase motors with internal overload protection, integral electric control panel, and disconnect switch. Control capacity by cycling fans.

Y. Glycol Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing two centrifugal pumps with mechanical seals; electrical-control cabinet with starters, disconnect switch, lead-lag switch, automatic switchover, and alarm light.
   1. Piping: Interconnecting piping, from suction to discharge, with shutoff valves, flow switches, check valves in pump discharge, unions, and pressurized expansion tank with air purge vent and system-charging connection.

Z. Integral Electrical Controls: Unit-mounted electrical enclosure with piano-hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control-circuit transformer.

AA. Disconnect Switch (Locking Type): Provide a non-automatic molded case circuit breaker mounted in the high voltage section of the electrical panel. The switch shall be accessible from the outside of the unit with the accent panel closed, and prevent access to the high voltage electrical components until switched to the "OFF" position.

BB. Smoke Detector: Provide a smoke detector which shall immediately shut down the environmental control system and activate the alarm system when activated. The smoke detector shall be mounted in the electrical panel with the sensing element in the return air compartment.

CC. Firestat: Provide a firestat which shall immediately shut down the environmental control system when activated. The firestat shall be mounted in the electrical panel with the sensing element in the return air.

DD. Microprocessor-Control System: Continuously monitors operation of process cooling system; continuously displays room temperature and room relative humidity; sounds alarm on system malfunction and simultaneously displays problem. If more than one malfunction occurs, system displays fault in sequence with room temperature and continues to display fault when malfunction is cleared until system is reset.
   1. Malfunctions:
      a. Power Loss.
      b. Loss of Airflow.
      c. Clogged Air Filter.
2.3 FLOOR-MOUNTING UNITS 5 TONS (18 KW) AND SMALLER

A. Manufacturers:
   1. Data Aire, Inc.
   2. Liebert Corporation.
   3. Stulz Investment Corp. of America.

B. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in upflow or downflow configuration.

C. Cabinet: Welded tubular-steel frame with removable steel panels. All frame and internal components shall be coated using an autophoretic process to protect against corrosion baked-enamel finish, and insulated with 1-inch (25-mm) thick duct liner.

D. Floor Stand: For downflow units, provide a welded tubular steel floor stand. Coordinate stand height with raised floor elevation(s).

E. Evaporator Fan: Provide centrifugal type fan, double width, double inlet. The shaft shall be heavy duty steel with self-aligning ball bearings with a minimum life span of 100,000 hours. The fan motor shall be mounted on an adjustable slide base. The drive package shall be variable speed. The fans shall be located to draw air over the A-frame coil to ensure even air distribution and maximum coil performance. Forward curved, centrifugal, with adjustable V-belt drive.

   1. Motor: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
F. Refrigeration System: Provide refrigeration system consisting of high efficiency scroll compressor, high and low pressure safety switches, externally equalized expansion valve, filter dryer, crankcase heater, and a refrigerant sight glass and moisture indicator.

G. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
   1. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
   2. Refrigerant: R-407C or R-410A.

H. Evaporator Coil: Direct-expansion cooling coil of seamless copper tubes expanded into aluminum fins, with one two circuits, each with solenoid valve. Mount coil assembly over stainless-steel drain pan having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.

I. Water-Cooled Condenser: Brazed-plate type with liquid-line stop valve and head-pressure-actuated, water-regulating valve.

J. Outdoor Water or Glycol Cooled Condenser: Provide a low profile, slow speed, multiple, direct drive propeller fan drycooler. The drycooler shall be constructed of aluminum and contain a copper tube, aluminum fin coil with an integral electric control panel. Provide a centrifugal pump mounted in a weatherproof and vented enclosure. Provide a crankcase heater.

K. Indoor Water or Glycol Cooled Condenser: Provide a prepiped condenser circuit with a head pressure actuated 2 way or 3 way water regulating valve. Provide a crankcase heater.

L. Outdoor Air Cooled Condenser: Provide slow speed, multiple direct drive propeller fan air cooled condenser. The condenser shall be constructed of aluminum and contain a copper tube, aluminum fin coil with an integral electric control panel. Winter control shall be fan speed control. The control system shall be complete with transducers, thermostats and electrical control circuit, factory prewired and tested in an integral control panel. The transducer shall automatically sense the head pressure of the compressor and control the variable speed fan on the air cooled condenser to properly maintain the head pressure. The fan speed control system shall provide positive start-up and operation in ambient temperature as low as -20 degrees F. Provide a solid state winter start kit as an integral feature of the electronic control panel. Provide a liquid line solenoid valve for pump down control.

M. Winter Control System: Provide a winter control system for the air cooled condenser. The system shall allow start-up and positive head pressure control with ambient temperatures as low as -30 degrees F. The control system shall include, for each circuit, insulated receivers, pressure relief valves, head pressure three-way control valves and rotoloc valves for isolating the refrigerant charge. The receivers shall be factory insulated and mounted ready for the field connection to the air cooled condenser.

N. Air-Cooled Condenser: Integral copper-tube aluminum-fin coil with propeller fan, direct driven.
   1. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

O. Chilled-Water Coil: Seamless copper tubes expanded into aluminum fins with modulating control valve. Mount coil assembly over stainless-steel drain pan having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.

P. Glycol Cooling Coil: Seamless copper tubes expanded into aluminum fins with three-way control valve.
Q. Electric Reheat: Provide low-watt intensity finned tubular stainless steel electric reheat coils capable of maintaining room dry bulb conditions when the system is calling for dehumidification. The reheat section shall include U.L. approved safety switches to protect the system from overheating.

R. Filter: 2-inch- (50-mm-) thick, disposable, glass-fiber media with 20 percent dust-spot efficiency.

S. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepped and located in bypass airstream; with flush-cycle timer and solenoid drain valve.

T. Auto Flush System: Provide auto flush system which shall automatically flush deposits from the humidifier pan. The system shall be field adjustable to change the cycle time to suit local water conditions.

U. Remote Glycol Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motors with internal overload protection.

V. Glycol Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.
1. Piping: Interconnecting piping, from suction to discharge, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.

W. Advanced Microprocessor Control: The advanced control processor shall be microprocessor based with a front monitor LCD display panel and control keys for user inputs. The controls shall be menu driven with on-screen prompts for easy user operation. The system shall allow user review and programming of temperature and humidity setpoints, alarm parameters, and setup selections including choice of control type. A password shall be required to make system changes. For all user selections, the range of acceptable input (temperature, humidity, or time delay) shall be displayed on the monitor screen. The system shall provide monitoring of room conditions, operational status in % of each function, component run times, date and time, and four analog inputs from sensors provided by others.
1. Control: The control system shall allow programming of the following room conditions.
   a. Temperature Setpoint 65 to 85 degrees F (18-29 degrees C).
   b. Temperature Sensitivity +1 to +9.9 degrees F (0.6 to 5.6 degrees C) in 0.1 degrees increments.
   c. Humidity Setpoint 20 to 80 percent RH.
   d. Humidity Sensitivity +1 to +30 degree RH.
   e. All setpoints shall be adjustable from the individual unit front monitor panel. Temperature and humidity sensors shall be capable of being calibrated using the front monitor panel controls to coordinate with other temperature and humidity sensors in the room.
2. Compressor Short-Cycle Control: The control system shall include a program to prevent compressor short-cycling.
3. System Auto-Restart: For start-up after power failure, the system shall provide automatic restart with a programmable (up to 9.9 minutes in 6-second increments) time delay. Programming can be performed either at the unit or from a central site monitoring system.
4. Sequential Load Activation: During start-up, or after power failure, the microprocessor shall sequence operational load activation to minimize inrush current. Systems allowing multiple loads to start simultaneously are not acceptable.
5. **Front Monitor Display Panel:** The microprocessor shall provide a font monitor LCD backlit display panel with 4 rows of 20 characters with adjustable contrast. This display (along with five front mounted control keys) shall be the only operator interface required to obtain all available system information such as room conditions, operational status, alarms, control and alarm setpoints, and all user selections including alarm delays, sensor calibration, DIP switch selections, and diagnostics. All indicators shall be in language form. No symbols or codes shall be acceptable.

6. **Alarms:** The microprocessor shall activate an audible and visual alarm in event of any of the following conditions.
   - High Temperature.
   - Low Temperature.
   - High Humidity.
   - Low Humidity.
   - Short Cycle.
   - Compressor Overload (Optional).
   - Main Fan Overload (Optional).
   - Humidifier Problem.
   - High Head Pressure.
   - Change Filter.
   - Loss of Air Flow.
   - Low Suction Pressure.
   - Loss of Power.

7. **Diagnostics:** The control system and electronic circuitry shall be provided with self-diagnostics to aid in troubleshooting. The microcontroller board shall be diagnosed and reported as pass/not pass. Control inputs shall be indicated as on or off at the front monitor panel. Control outputs shall be able to be turned on or off from the front monitor panel without using jumpers or a service terminal. Each control output shall be indicated by an LED on a circuit board.

8. Provide an interface to allow connection to the FMLH Building Automation System.

### 2.4 CEILING-MOUNTING UNITS

**A. Manufacturers:**

1. Data Aire, Inc.
2. Liebert Corporation.
3. Stulz Investment Corp. of America.

**B. Description:** Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for horizontal ceiling mounting to fit 24-by-48-inch (610-by-1220-mm) T-bar ceiling opening.

**C. Cabinet:** Galvanized steel with baked-enamel finish, insulated with 1/2-inch-(15-mm-) thick duct liner.

**D. Cabinet and Chassis:** Provide cabinet and chassis constructed of heavy gauge galvanized steel and designed for easy installation and service access. Cabinet shall provide service access from one side only.

**E. Air Distribution System:** Provide air distribution system constructed with direct drive fan assembly equipped with multiple, double-inlet blowers, self-aligning sleeve bearings and lifetime lubrication. Fan motor shall be permanent-split, high efficiency type, equipped with two speeds for air flow modulation. Dehumidification shall utilize the lower fan speed.
F. Air Filters (ducted systems only): Provide air filters disposable 4 inch deep pleated type with a minimum efficiency of 20 percent based on ASHRAE 52-76. They shall be easily removable from the system and shall not require system shutdown for service.

G. Evaporator Fan: Forward curved, centrifugal, and directly driven by two-speed motor.
   1. Motor: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

H. Refrigeration System: Provide refrigeration system split between evaporator and condenser sections. Both systems shall be factory piped and sealed with an operating charge. Connection of the evaporator and condenser sections shall not require brazing, dehydration or charging. Refrigerant line sets shall be provided in proper lengths for application.

I. Compressor: Hermetic, with resilient suspension system, oil strainer, and internal motor overload protection.
   1. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
   2. Refrigerant: R-407C or R-410A.

J. Evaporator Coil: Direct-expansion cooling coil of seamless copper tubes expanded into aluminum fins. Mount coil assembly over stainless-steel drain pan having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.

K. Water-Cooled Condenser: Coaxial, counterflow, tube-in-tube or brazed-plate type with liquid-line stop valve and head-pressure-actuated, water-regulating valve.

L. Condensing Unit: Provide condensing unit containing the compressor and heat rejection equipment. All components shall be factory assembled, charged with refrigerant and sealed. The compressor shall be fully hermetic with overloads, manual reset high pressure switch, spring isolation, crankcase heater. The refrigeration circuit shall also include filter drier, refrigerant line sight glass and moisture indicator.

M. Propeller Fan Air Cooled Condensing Unit: Provide condenser coil constructed of copper tubes and aluminum fins with a direct-drive propeller-type fan. All components shall be factory assembled, charged with refrigerant, sealed and be capable of being connected to the evaporator section using pre-charged refrigerant line sets. No piping, brazing, dehydration or charging shall be required. Condenser shall be designed for 95 degree F ambient and be capable of operation to minus 30 degrees F.

N. Water or Glycol Cooled Condensing Unit: Provide water/glycol cooled condensing unit including the compressor and the water (glycol) cooled condenser and capable of being connected to the evaporator module using pre-charged refrigerant line sets. Provide an adjustable water regulating valve. The entire system shall be factory piped, charged with refrigerant and sealed. No piping, brazing, dehydration or charging shall be required.

O. Air-Cooled Condenser: Integral copper-tube aluminum-fin coil with propeller fan, direct driven.
   1. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

P. Chilled-Water Coil: Seamless copper tubes expanded into aluminum fins with modulating control valve. Mount coil assembly over stainless-steel drain pan having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.
Q. Electric Reheat: Provide electric reheat of low-watt density with tubular construction and provided with non-corrosive metal sheath. The capacity of the reheat shall be capable of maintaining dry-bulb conditions but shall only be energized if dry-bulb temperature drops below thermostat set point. Safety switches shall be provided to provide for shutdown in event of over-temperature conditions.

R. Filter: Pleated, 2-inch- (50-mm-) thick, disposable.

S. Steam Generating Humidifier: Provide steam-generating humidifier factory piped, mounted and wired to the integral control system. The steam generator shall provide dry steam to the bypass air around the evaporator coil. Controls for the humidification system shall include: high and low humidity setpoints with adjustable deadband, automatic water feed and drain valves.

T. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap on drain.
2. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
3. Drain Cycle: Field-adjustable drain duration and drain interval.

U. Air Distribution Plenum: Provide evaporator section with an air distribution plenum with integral filter. Plenum shall be 2 feet x 4 feet in size and provide 4 way air distribution. Filters shall be 4 inch deep pleated type with a minimum efficiency of 20 percent based on ASHRAE 52-76.

V. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature- and humidity-control modules, humidity contactor, time-delay relay, reheat contactor, and high-temperature thermostat. Provide solid-state, wall-mounting control panel with start-stop switch, adjustable humidity set point, and adjustable temperature set point.

1. Additional Monitoring:
   a. Monitor constant and variable motor loads.
   b. Monitor variable frequency drive operation.
   c. Monitor cooling load.
   d. Monitor economizer cycles.
   e. Monitor air distribution static pressure and ventilation air volumes.

2. Provide an interface to allow connection to the FMLH Building Automation System.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install computer room air-conditioning units level and plumb, maintaining manufacturer's recommended clearances. Install according to ARI Guideline B.

B. Curb Support: Install and secure roof-mounting units on curbs and coordinate roof penetrations and flashing with roof construction.

C. Install suspended components level. Coordinate wall penetrations and flashing with wall construction.
D. Install air-cooled condenser on vibration devices specified in Division 23 Section "Vibration Controls for HVAC."

E. Install remote glycol cooler on vibration devices specified in Division 23 Section "Vibration Controls for HVAC."

F. Install glycol pump package on vibration devices specified in Division 23 Section "Vibration Controls for HVAC."

G. Install floor-mounting units on bases required by Division 23 Section "Vibration Controls for HVAC."

H. Support suspended units from structure using vibration control and restraint devices specified in Division 23 Section "Vibration Controls for HVAC."

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Water and Drainage Connections: Comply with applicable requirements in Division 23 Section "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.

D. Hot-Water Heating Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Provide shutoff valves in inlet and outlet piping to reheat coils.

E. Condenser-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Provide shutoff valves in water inlet and outlet piping on water-cooled units.

F. Refrigerant Piping: Comply with applicable requirements in Division 23 Section "Refrigerant Piping." Provide shutoff valves and piping.

G. Electrical System Connections: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.

H. Ground equipment according to Division 26 Section "Grounding and Bonding."

I. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   2. After installing computer room air-conditioning units and after electrical circuitry has been energized, test for compliance with requirements.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3.4 STARTUP SERVICE
   A. Engage a factory-authorized service representative to perform startup service.
   B. Verify that computer room air-conditioning units are installed and connected according to
      manufacturer's written instructions and the Contract Documents.
   C. Verify that electrical wiring installation complies with manufacturer's submittal and installation
      requirements in Division 26 Sections.
   D. Complete installation and startup checks according to manufacturer's written instructions.
   E. After startup service and performance test, change filters and flush humidifier.

3.5 ADJUSTING
   A. Adjust initial temperature and humidity set points.
   B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
   C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion,
      provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to
      two visits to site outside normal occupancy hours for this purpose, without additional cost.

3.6 DEMONSTRATION
   A. Engage a factory-authorized service representative to train Owner's maintenance personnel to
      adjust, operate, and maintain computer room air-conditioning units. Refer to Division 01
      Section "Demonstration and Training."

END OF SECTION 238123
SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.

1.2 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS
A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
B. Shop Drawings:
   1. Wiring Diagrams: Diagram power, signal, and control wiring.
C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS
A. Field Quality Control Test Reports.

1.5 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.
   1. Special Warranty Information: Special warranty specified in this Section.

1.6 QUALITY ASSURANCE
A. Product Options: Drawings indicate size, profiles, and dimensional requirements of split-system units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2007, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
D. ASHRAE/IESNA 90.1-2013 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2013, Section 6 - "Heating, Ventilating, and Air-Conditioning."
1.7 COORDINATION
A. Coordinate size and location of concrete bases for units. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."
B. Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations specified in Division 07 Section "Roof Accessories."

1.8 WARRANTY
A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Five years from date of Substantial Completion.

1.9 EXTRA MATERIALS
A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Filters: One set of filters for each unit.
2. Fan Belts: One set of belts for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Mitsubishi Electric Sales Canada, Inc.
2. Mitsubishi Electronics America, Inc.; HVAC Division.
3. Mitsubishi Heavy Industries America, Inc.; Air-Conditioning & Refrigeration Division, Inc.
5. Trane Company (The); Unitary Products Group.

2.2 CONCEALED EVAPORATOR-FAN COMPONENTS
A. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
1. Insulation: Faced, glass-fiber duct liner.
B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
C. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; and having a two-position control valve.
D. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.

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E. Fan Motors: Provide unit with electrically-commutated (EC) motor. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

F. Disposable Filters: Pleated filter, 1 inch (25 mm) thick, in fiberboard frames with ASHRAE 52.2 MERV rating of 6 or higher.

G. Wiring Terminations: Connect motor to chassis wiring with plug connection.

2.3 FLOOR-MOUNTING, EVAPORATOR-FAN COMPONENTS

A. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect.
   1. Discharge Grille: Steel with surface-mounted frame.
   2. Insulation: Foil Faced, glass-fiber, duct liner.

B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

C. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; and having a 2-position control valve.

D. Fan: Direct drive, centrifugal.

E. Fan Motors: Provide unit with electrically-commutated (EC) motor. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

F. Disposable Filters: Pleated filter, 1 inch (25 mm) thick, in fiberboard frames with ASHRAE 52.2 MERV rating of 6 or higher.

2.4 WALL-MOUNTING, EVAPORATOR-FAN COMPONENTS

A. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
   1. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.

B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

C. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.

D. Fan: Direct drive, centrifugal fan.

E. Fan Motors: Provide unit with electrically-commutated (EC) motor. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

F. Disposable Filters: Pleated filter, 1 inch (25 mm) thick, in fiberboard frames with ASHRAE 52.2 MERV rating of 6 or higher.
2.5 CEILING-MOUNTING, EVAPORATOR-FAN COMPONENTS
   A. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
      1. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.
   B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
   C. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
   D. Fan: Direct drive, centrifugal fan and integral condensate pump.
   E. Fan Motors: Provide unit with electrically-commutated (EC) motor. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   F. Disposable Filters: Pleated filter, 1 inch (25 mm) thick, in fiberboard frames with ASHRAE 52.2 MERV rating of 6 or higher.

2.6 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS
   A. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
   B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
      1. Compressor Type: Scroll.
      2. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
      3. Refrigerant: R-407C or R-410A.
   C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
   D. Heat Pump Components: Reversing valve and low-temperature air cut-off thermostat.
   E. Fan: Aluminum-propeller type, directly connected to motor.
   F. Motor: Permanently lubricated, with integral thermal-overload protection.
   G. Low Ambient Kit: Permits operation down to 0 deg F (-18 deg C).
   H. Mounting Base: Polyethylene.
2.7 WATER-COOLED, COMPRESSOR-CONDENSER COMPONENTS
A. Casing: Steel, with baked-enamel finish in color selected by Architect, removable panels for access to controls, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
   1. Compressor Type: Scroll.
   2. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
   3. Refrigerant: R-407C or R-410A.
C. Heat Pump Components: Reversing valve.
D. Heat Exchanger: Copper tubes in copper tube or in steel shell, with water-temperature-actuated, water-regulating valve.

2.8 ACCESSORIES
A. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
C. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
   1. Compressor time delay.
   2. 24-hour time control of system stop and start.
   3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
   4. Fan-speed selection, including auto setting.
D. Automatic-reset timer to prevent rapid cycling of compressor.
E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
   1. Minimum Insulation Thickness: 1 inch thick.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install units level and plumb.
B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
C. Install ground-mounting, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base; 4 inches (100 mm) larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.
D. Install ground-mounting, compressor-condenser components on polyethylene mounting base.

E. Install roof-mounting compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

F. Install restraints required by Division 23 Section "Vibration Controls for HVAC."

G. Install compressor-condenser components on vibration isolation devices according to Division 23 Section "Vibration Controls for HVAC."

H. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Water Coil Connections: Comply with requirements in Division 23 Section "Hydronic Piping." Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

2. Remote Water-Cooled Condenser Connections: Comply with requirements in Division 23 Section "Hydronic Piping." Connect to supply and return with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

B. Install piping adjacent to unit to allow service and maintenance.

C. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply[ and return] ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories."

D. Ground equipment according to Division 26 Section "Grounding and Bonding."

E. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.
3.4 STARTUP SERVICE
   A. Engage a factory-authorized service representative to perform startup service.
      1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION
   A. Engage a factory-authorized service representative to train Owner's maintenance personnel to
      adjust, operate, and maintain units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238126
SECTION 238146 - WATER-SOURCE UNITARY HEAT PUMPS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following types of water-source heat pumps:
   1. Concealed horizontal or vertical units, 6 tons (21 kW) and smaller.
   2. Concealed horizontal or vertical units, larger than 6 tons (21 kW).
   3. Rooftop units.

1.2 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS
A. Product Data: Include rated capacities, furnished specialties, and accessories for each model.
B. Product Certificates: For each type of water-source heat pump, signed by product manufacturer.
C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
D. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which heat pumps will be attached.
   3. Method of attaching hangers to building structure.
   4. Size and location of initial access modules for acoustical tile.
   5. Items penetrating finished ceiling, including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.

1.4 INFORMATIONAL SUBMITTALS
A. Field Quality Control Test Reports.

1.5 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For water-source heat pumps to include in emergency, operation, and maintenance manuals.
   1. Special Warranty Information: Special warranty specified in this Section.
1.6 QUALITY ASSURANCE
A. Product Options: Drawings indicate size, profiles, and dimensional requirements of water-source heat pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
   1. Do not modify intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If modifications are proposed, submit comprehensive explanatory data to Architect for review.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
C. Comply with the latest edition of ASHRAE 15.
D. Comply with minimum COP/efficiency levels according to ASHRAE/IESNA 90.1-2013.
E. Comply with NFPA 70.
F. Comply with safety requirements in UL 484 for assembly of free-delivery water-source heat pumps.
G. Comply with safety requirements in UL 1995 for duct-system connections.

1.7 COORDINATION
A. Coordinate layout and installation of water-source heat pumps and suspension components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system components, and partition assemblies.
B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.8 WARRANTY
A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water-source heat pumps that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, refrigeration components.
   2. Warranty Period: One year from date of Substantial Completion.

1.9 EXTRA MATERIALS
A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. One set of matched fan belts for each belt-driven fan.
   2. One set of filters for each unit.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CONCEALED WATER-SOURCE HEAT PUMPS, 6 TONS (21 KW) AND SMALLER

A. Manufactures:
   1. ClimateMaster, Inc.
   2. Bosch Group – Florida Heat Pump
   4. Trane.

B. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ARI-ISO-13256-1.

C. Cabinet and Chassis: Galvanized-steel casing with the following features:
   1. Access panel for access and maintenance of internal components.
   2. Knockouts for electrical and piping connections.
   3. Flanged duct connections.
   4. Cabinet Insulation: Glass-fiber liner, minimum 1/2 inch (13 mm) thick, complying with UL 181.
   5. Condensate Drainage: Plastic or stainless-steel drain pan pitched as required in ASHRAE 62.1-2007 with condensate drain piping projecting through unit cabinet.
   6. Sound Attenuation Package:
      a. Minimum 0.598-inch- (1.5-mm-) thick compressor enclosure and front panel. Minimum 0.0937-inch- (2.38-mm-) thick foam gasket around the compressor and perimeter of end panel.
      b. Sound attenuating blanket over compressor.
      c. Hot-gas muffler.

D. Fan: Direct driven, centrifugal, with multispeed motor resiliently mounted in fan inlet.
   1. General requirements for motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

E. Water Circuit:
   1. Refrigerant-to-Water Heat Exchangers:
      a. Coaxial heat exchangers with [copper][cupronickel] water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube leak tested to 450 psig (3102 kPa) on refrigerant side and 400 psig (2758 kPa) on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
      b. Stainless-steel, brazed-plate heat exchanger leak tested to 450 psig (3102 kPa) for refrigerant side and 400 psig (2758 kPa) for water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
2. Water-Side Economizer: Copper tube and aluminum fin coil with three-way valve and entering-water temperature sensor and controller. Valve diverts water to water-side economizer coil ahead of refrigerant-to-water heat exchanger when entering-water temperature falls to 55 deg F (13 deg C).

3. Water Regulating Valves: Limit water flow through refrigerant-to-water heat exchanger, and control head pressure on compressor during cooling and heating. Valves shall close when heat-pump compressor is not running.

4. Motorized Water Valve: Stop water flow through the unit when compressor is off.

F. Refrigerant-to-Air Coils: Copper tubes with aluminum fins, leak tested to 450 psig (3102 kPa).

G. Refrigerant Circuit Components:
   2. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.
   3. Charging Connections: Service fittings on suction and liquid for charging and testing.
   4. Reversing Valve: Pilot-operated sliding-type valve designed to be fail-safe in heating position with replaceable magnetic coil.
   5. Compressor: Hermetic scroll compressor installed on vibration isolators and housed in an acoustically treated enclosure with factory-installed safeties as follows:
      a. Antirecycle timer.
      b. High-pressure cutout.
      c. Low-pressure cutout or loss of charge switch.
      d. Internal thermal-overload protection.
      e. Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below 35 deg F (2 deg C).
      f. Condensate overflow switch to stop compressor with high condensate level in condensate drain pan.
   7. Pipe Insulation: Refrigerant minimum 3/8-inch- (10-mm-) thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-development indexes according to ASTM E 84.
   9. Refrigerant Metering Device: Thermal expansion valve to allow specified operation with entering-water temperatures from 25 to 125 deg F (minus 4 to plus 52 deg C).

H. Filters: Disposable, pleated type, 1 inch (25 mm) thick and with a minimum of 90 percent arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value of 7 according to ASHRAE 52.2.

I. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

J. Controls:
   1. Basic Unit Controls:
      a. Low- and high-voltage protection.
      b. Overcurrent protection for compressor and fan motor.
      c. Random time delay, three to ten seconds, start on power up.
      d. Time delay override for servicing.
      e. Control voltage transformer.
2. Thermostat:
   a. Wall-Mounted Thermostat:
      1) Heat-cool-off switch.
      2) Fan on-auto switch.
      3) Automatic changeover.
      4) Exposed temperature set point.
      5) Exposed temperature indication.
      6) Deg F indication.
   b. Wall-mounted temperature sensor.
   c. Unoccupied period override push button.
   d. LED to indicate fault condition at heat pump.
   e. Data entry and access port.
      1) Input data include room temperature and humidity set points for occupied and unoccupied periods.
      2) Output data include room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

3. Terminal Controller:
   a. Scheduled operation for occupied and unoccupied periods on 365-day clock with minimum 4 programmable periods per day.
   b. Two-hour unoccupied period override period.
   c. Remote control panel to contain programmable timer and LED for fault condition.
   d. Compressor disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
   e. Automatic restart after five minutes if fault clears. Indicate fault for service technician.
   f. Return-air temperature high-limit (firestat). Stop unit on high temperature.
   g. Backup for volatile memory.
   h. Differential pressure switch to indicate filter status. Dirty filter alarm.
   i. Differential pressure switch to indicate fan status. Fan failure alarm.

4. BAS interface requirements as further described in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
   a. Interface relay for scheduled operation.
   b. Interface relay to provide indication of fault at central workstation.
   c. Provide BAC-net interface for central BAS workstation for the following functions:
      1) Set-point adjustment for set points identified in this Section.
      2) Start/stop and operating status of heat-pump unit.
      3) Data inquiry to include supply air, room air temperature and humidity, and entering-water temperature.
      4) Occupied and unoccupied schedules.

K. Electrical Connection: Single electrical connection with fused disconnect.
L. Capacities and Characteristics: Refer to Drawings.

2.3 CONCEALED WATER-SOURCE HEAT PUMPS, LARGER THAN 6 TONS (21 KW)
A. Manufacturers:
   1. ClimateMaster, Inc.
2. Bosch Group – Florida Heat Pump
4. Trane.

B. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ARI-ISO-13256-1.

C. Cabinet and Chassis: Galvanized-steel casing with the following features:
   1. Access panel for access and maintenance of internal components.
   2. Knockouts for electrical and piping connections.
   3. Flanged duct connections.
   4. Cabinet Insulation: Glass-fiber liner, 1 inch (25 mm) thick, complying with UL 181.
   6. Sound Attenuation Package:
      a. Minimum 0.598-inch- (1.5-mm-) thick compressor enclosure and front panel. Minimum 0.0937-inch- (2.38-mm-) thick foam gasket around the compressor and perimeter of end panel.
      b. Sound attenuating blanket over compressor.
      c. Hot-gas muffler.

D. Fan: Belt driven, centrifugal, with single-speed motor installed on an adjustable fan base resiliently mounted in cabinet.
   1. General requirements for motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

E. Water Circuit:
   1. Refrigerant-to-Water Heat Exchanger:
      a. Coaxial or Shell-and-tube heat exchanger with [copper][cupronickel] water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube leak tested to 450 psig (3102 kPa) on refrigerant side and 400 psig (2758 kPa) on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
      b. Stainless-steel brazed plate heat exchanger leak tested to 450 psig (3102 kPa) on refrigerant side and 400 psig (2758 kPa) on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
   2. Water-Side Economizer: Copper tube and aluminum fin coil leak tested at 400 psig (2758 kPa) with 3-way valve and entering-water temperature sensor and controller. Valve diverts water to water-side economizer coil ahead of refrigerant-to-water heat exchanger when entering-water temperature falls to 55 deg F (13 deg C).
   3. Water Regulating Valves: Limit water flow through refrigerant-to-water heat exchanger, and control head pressure on compressor during cooling and heating. Valves shall close when heat-pump compressor is not running.
   4. Motorized Water Valve: Stop water flow through the unit when compressor is off.

F. Refrigerant-to-Air Coils: Copper tubes with aluminum fins, leak tested to 450 psig (3102 kPa).

G. Refrigerant Circuit Components:
   1. Sealed Refrigerant Circuit: Charge with R-407C or R-410A refrigerant. Minimum of 2 circuits required for units 10 tons (35 kW) and larger. Intertwine circuits in refrigerant to air coil.
2. Filter-Dryer: Factory installed to clean and dehydrate each refrigerant circuit.
3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
4. Reversing Valve: Pilot-operated sliding-type valve designed to be fail-safe in heating position with replaceable magnetic coil.
5. Compressor: Hermetic scroll compressor installed on vibration isolators housed in an acoustically treated enclosure with factory-installed safeties as follows:
   a. Antirecycle timer.
   b. High-pressure cutout.
   c. Low-pressure cutout or loss of charge switch.
   d. Internal thermal-overload protection.
   e. Freezeastat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below 35 deg F (2 deg C).
   f. Condensate overflow switch to stop compressor with high condensate level in condensate drain pan.
7. Pipe Insulation: Refrigerant minimum 3/8-inch (10-mm-) thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-development indexes per ASTM E 84.
9. Refrigerant Metering Device: Thermal expansion valve to allow specified operation with entering-water temperatures from 25 to 125 deg F (minus 4 to plus 52 deg C).

H. Electric Heating Coil: Helix-wound, nickel-chromium wire-heating elements in ceramic insulators mounted on steel supports. Energize on call for heating when entering-water-loop temperature is less than 40 deg F (5 deg C).
I. Hot-Gas Reheat: Reheat valve diverts refrigerant hot gas to reheat coil when remote humidistat calls for dehumidification.
J. Hot-Gas Bypass: Include constant pressure expansion valve, solenoid valve, and controls to maintain continuous refrigeration system operation at 10 percent of full load on lead compressor.
K. Filters: Disposable, pleated type, 2 inches (50 mm) thick and with a minimum of 90 percent arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value of 7 according to ASHRAE 52.2.
L. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

M. Controls:
   1. Basic Unit Controls:
      a. Low- and high-voltage protection.
      b. Overcurrent protection for compressor and fan motor.
      c. Random time delay, three to ten seconds, start on power-up.
      d. Time delay override for servicing.
      e. Control voltage transformer.
2. Thermostat:
   a. Wall-Mounted Thermostat:
      1) Heat-cool-off switch.
      2) Fan on-auto switch.
      3) Automatic changeover.
      4) Exposed temperature set point.
      5) Exposed temperature indication.
      6) Deg F indication.
      7) Two-stage heating.
      8) Two-stage cooling.
   b. Wall-mounted temperature sensor.
   c. Unoccupied period override push button.
   d. LED to indicate fault condition at heat pump.
   e. Data entry and access port.
      1) Input data include room temperature and humidity set points for occupied and unoccupied periods.
      2) Output data include room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

3. Terminal Controller:
   a. Scheduled operation for occupied and unoccupied periods on 365-day clock with minimum 4 programmable periods per day.
   b. Two-hour unoccupied period override period.
   c. Remote control panel to contain programmable timer and LED for fault condition.
   d. Compressor disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
   e. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
   f. Return-air temperature high-limit (firestat). Stop unit on high temperature.
   g. Smoke alarm with smoke detector installed in supply and return air. Stop unit on smoke detection.
   h. Backup for volatile memory.
   i. Differential pressure switch to indicate fan status. Fan failure alarm.
   j. Differential pressure switch to indicate filter status. Dirty filter alarm.

4. BAS interface requirements as further described in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
   a. Interface relay for scheduled operation.
   b. Interface relay to provide indication of fault at central workstation.
   c. Provide BAC-net interface for central BAS workstation for the following functions:
      1) Set-point adjustment for set points identified in this Section.
      2) Start/stop and operating status of heat-pump unit.
      3) Data inquiry to include supply air, room air temperature and humidity, and entering-water temperature.
      4) Occupied and unoccupied schedules.

N. Electrical Connection: Single electrical connection with fused disconnect.
O. Capacities and Characteristics: Refer to Drawings.
2.4 ROOFTOP WATER-SOURCE HEAT PUMPS

A. Manufacturers:
1. ClimateMaster, Inc.
2. Bosch Group – Florida Heat Pump
3. Mammoth Inc.
5. Trane.

B. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ARI-ISO-13256-1.

C. Cabinet and Chassis: Galvanized-steel casing with the following features:
1. Water- and air-tight access panels for access and maintenance of internal components.
2. Knockouts for electrical and piping connections.
3. Flanged duct connections.
4. Cabinet Insulation: Glass-fiber liner, 1 inch (25 mm) thick, complying with UL 181.

D. Indoor Fan: Forward curved centrifugal, with direct-drive, multispeed motor resiliently mounted in fan inlet.
1. General requirements for motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
2. Direct-Drive Fan Motor: Multispeed, permanently lubricated, ECM motor.

E. Water Circuit:
1. Refrigerant-to-Water Heat Exchanger:
   a. Coaxial or Shell-and-tube [copper][cupronickel] water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube leak tested to 450 psig (3102 kPa) on refrigerant side and 400 psig (2758 kPa) on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
   b. Stainless-steel brazed plate heat exchanger leak tested to 450 psig (3102 kPa) on refrigerant side and 400 psig (2758 kPa) on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
2. Water Regulating Valves: Limit water flow through refrigerant-to-water heat exchanger, and control head pressure on compressor during cooling and heating. Valves shall close when heat-pump compressor is not running.
3. Motorized Water Valve: Stop water flow through the unit when compressor is off.

F. Refrigerant-to-Air Coils: Copper tubes with aluminum fins, leak tested to 450 psig (3102 kPa).

G. Refrigerant Circuit Components:
1. Sealed Refrigerant Circuit: Charge with R-407C or R-410A refrigerant. Minimum of 2 circuits required for units 10 tons (35 kW) and larger. Intertwine circuits in refrigerant to air coil.
2. Filter-Dryer: Factory installed to clean and dehydrate each refrigerant circuit.
3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
4. **Reversing Valve**: Pilot-operated sliding-type valve designed to be fail-safe in heating position with replaceable magnetic coil.

5. **Compressor**: Hermetic scroll compressor installed on vibration isolators housed in an acoustically treated enclosure with factory-installed safeties as follows:
   a. Antirecycle timer.
   b. High-pressure cutout.
   c. Low-pressure cutout or loss of charge switch.
   d. Internal thermal-overload protection.
   e. Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below 35 deg F (2 deg C).
   f. Condensate overflow switch to stop compressor with high condensate level in condensate drain pan.


7. **Pipe Insulation**: Refrigerant minimum 3/8-inch (10-mm-) thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-development indexes per ASTM E 84.

8. **Refrigerant Metering Device**: Capillary tube.

9. **Refrigerant Metering Device**: Thermal expansion valve to allow specified operation with entering-water temperatures from 25 to 125 deg F (minus 4 to plus 52 deg C).

10. **Hot-Gas Reheat Valve**: Pilot-operated sliding-type valve with replaceable magnetic coil.

H. **Electric Heating Coil**: Helix-wound, nickel-chromium wire-heating elements in ceramic insulators mounted on steel supports. Energize on call for heating when entering-water-loop temperature is less than 40 deg F (5 deg C).

I. **Hot-Gas Reheat**: Reheat valve diverts refrigerant hot gas to reheat coil when remote humidistat calls for dehumidification.

J. **Hot-Gas Bypass**: Include constant pressure expansion valve, solenoid valve, and controls to maintain continuous refrigeration system operation at 10 percent of full load on lead compressor.

K. **Outdoor-Air Damper**: Linked damper blades, for minimum 25 percent outdoor air, with fully modulating, spring-return damper motor and hood.

L. **Air-Side Economizer**: Return-, relief-, and outdoor-air dampers with neoprene seals and with weather-resistant hood.
   1. **Damper Motors**: Fully modulating spring return with adjustable minimum position potentiometer.
   2. **Temperature Control**: Microprocessor-based controller using outdoor-air, mixed-air temperature and selects between outdoor-air and return-air enthalpy to adjust mixing dampers with water-loop entering temperature greater than 70 deg F (21 deg C). Delay opening outdoor-air damper to minimum position until room thermostat is satisfied at room set-point temperature.
   3. **Relief Damper**: Gravity-actuated damper with bird screen and hood.
   4. **Powered Relief**: Direct-drive propeller fan with PSC motor, normally closed motorized damper, and hood. Operate fan with building pressure greater than 0.05-inch wg (12.4 Pa).

M. **Filters**: Disposable, pleated type, 2 inches (50 mm) thick and with a minimum of 90 percent arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value of 7 according to ASHRAE 52.2.
N. Horizontal Discharge Roof Curb: Steel, with corrosion-protection coating, gasketing, and factory-installed wood nailer, and configured to convert from downflow to horizontal airflow; complying with NRCA standards; minimum height of 30 inches (760 mm).

O. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

P. Controls:

1. Basic Unit Controls:
   a. Low- and high-voltage protection.
   b. Overcurrent protection for compressor and fan motor.
   c. Random time delay, three to ten seconds, start on power-up.
   d. Time delay override for servicing.
   e. Control voltage transformer.

2. Thermostat:
   a. Wall-Mounted Thermostat:
      1) Heat-cool-off switch.
      2) Fan on-auto switch.
      3) Automatic changeover.
      4) Exposed temperature set point.
      5) Exposed temperature indication.
      6) Deg F indication.
      7) Two-stage heating.
      8) Two-stage cooling.
   b. Wall-mounted temperature sensor.
   c. Unoccupied period override push button.
   d. LED to indicate fault condition at heat pump.
   e. Data entry and access port.
      1) Input data include room temperature and humidity set points for occupied and unoccupied periods.
      2) Output data include room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

3. Terminal Controller:
   a. Scheduled operation for occupied and unoccupied periods on 365-day clock with minimum 4 programmable periods per day.
   b. Two-hour unoccupied period override period.
   c. Remote control panel to contain programmable timer and LED for fault condition.
   d. Compressor disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
   e. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
   f. Return-air temperature high-limit (firestat). Stop unit on high temperature.
   g. Smoke alarm with smoke detector installed in supply and return air. Stop unit on smoke detection.
   h. Backup for volatile memory.
   i. Differential pressure switch to indicate fan status. Fan failure alarm.
   j. Differential pressure switch to indicate filter status. Dirty filter alarm.
4. BAS interface requirements as further described in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
   a. Interface relay for scheduled operation.
   b. Interface relay to provide indication of fault at central workstation.
   c. Provide BAC-net interface for central BAS workstation for the following functions:
      1) Set-point adjustment for set points identified in this Section.
      2) Start/stop and operating status of heat-pump unit.
      3) Data inquiry to include supply air, room air temperature and humidity, and entering-water temperature.
      4) Occupied and unoccupied schedules.

Q. Electrical Connection: Single electrical connection with fused disconnect.
R. Capacities and Characteristics: Refer to Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of water-source heat pumps.
   B. Examine roughing-in for piping and electric installations for water-source heat pumps to verify actual locations of piping connections and electrical conduit before installation.
   C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
   A. Concrete Bases: Install floor mounting units on 4-inch-(100-mm-) high concrete bases. See Division 23 Section "Common Work Results for HVAC" for concrete base materials and fabrication requirements.
   B. Mount water-source heat pumps on concrete base with vibration isolators specified in Division 23 Section "Vibration Controls for HVAC."
   C. Suspend water-source heat pumps from structure with threaded steel rods and vibration isolators specified in Division 23 Section "Vibration Controls for HVAC."
   D. Curb Support: Install roof curb on roof structure, level and secure, according to ARI Guideline B. Install and secure rooftop water-source heat pumps on curbs and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.
   E. Isolation Curb Support: Install units on isolation curbs according to Division 23 Section "Vibration Controls for HVAC."
   F. Install wall-mounting thermostats, humidistats, and switch controls in electrical outlet boxes at heights to match lighting controls or as required in Division 23 Section "Instrumentation and Control for HVAC."

3.3 CONNECTIONS
   A. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
      1. Connect supply and return hydronic piping to heat pump with unions and shutoff valves.
2. Connect heat-pump condensate drain pan to indirect waste connection with condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

B. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts. Specific connection requirements are as follows:

1. Connect supply and return ducts to water-source heat pumps with flexible duct connectors specified in Division 23 Section "Air Duct Accessories."
2. Install ducts to termination in roof curb.
3. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
4. Terminate return-air duct through roof structure and insulate space between roof and bottom of unit with 2-inch (50-mm-) thick, acoustic duct liner.
5. Install normal-weight, 3000 psi (20.7 MPa), compressive-strength (28-day) concrete mix inside roof curb, 4 inches (100 mm) thick. Concrete, formwork, and reinforcement are specified in Division 03.

C. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

D. Install piping adjacent to machine to allow service and maintenance.

E. Ground equipment according to Division 26 Section "Grounding and Bonding."

F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. After installing water-source heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to compressor, coils, and fans.
3. Inspect internal insulation.
4. Verify that labels are clearly visible.
5. Verify that clearances have been provided for servicing.
6. Verify that controls are connected and operable.

WATER-SOURCE UNITARY HEAT PUMPS

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7. Verify that filters are installed.
8. Adjust vibration isolators.
9. Inspect operation of barometric dampers.
10. Verify bearing lubrication on fan.
11. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
12. Adjust fan belts to proper alignment and tension.
13. Start unit according to manufacturer's written instructions.
14. Complete startup sheets and attach copy with Contractor's startup report.
15. Inspect and record performance of interlocks and protective devices; verify sequences.
16. Operate unit for an initial period as recommended or required by manufacturer.
17. Verify thermostat and humidistat calibration.
18. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
19. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
20. Start refrigeration system and measure and record the following:
   a. Coil leaving-air, dry- and wet-bulb temperatures.
   b. Coil entering-air, dry- and wet-bulb temperatures.
   c. Outdoor-air, dry-bulb temperature.
   d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
21. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
   a. Supply-air volume.
   b. Return-air volume.
   c. Relief-air volume.
   d. Outdoor-air intake volume.

3.6 ADJUSTING
A. Adjust initial temperature and humidity set points.
B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

3.7 CLEANING
A. Replace filters used during construction prior to air balance or substantial completion.
B. After completing installation of exposed, factory-finished water-source heat pumps, inspect exposed finishes and repair damaged finishes.

3.8 DEMONSTRATION
A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water-source heat pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238146
SECTION 238213 – RADIANT HEATING AND COOLING PANELS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following:
   1. Electric radiant heaters.
   2. Prefabricated electric radiant heating panels.
   3. Hydronic heating panels.

1.2 DEFINITIONS
A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: Include rated capacities, specialties, and accessories for each product indicated.
B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work. Detail equipment assemblies and suspension and attachment. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
C. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which heaters and suspension systems will be attached.
   3. Size and location of initial access modules for acoustical tile.
   4. Items penetrating finished ceiling, including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
   5. Perimeter moldings.
D. Samples:
   1. Samples for Initial Selection: For units with factory-applied color finishes.
   2. Samples for Verification: For each type of exposed finish required, prepared on Samples of size indicated below.
      a. For Radiant Heater Finishes: 4 by 4 inches.
      b. For Radiant Panel Finishes: 12 by 12 inches.
1.5 INFORMATIONAL SUBMITTALS
   A. Field Quality Control Test Reports.

1.6 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For electric radiant heaters and panels to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.8 COORDINATION
   A. Coordinate layout and installation of radiant heaters and panels and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 ELECTRIC RADIANT HEATERS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Berko Electric Heating; a division of Marley Engineered Products.
      2. Chromalox Inc.; a division of Emerson Electric Company.
      3. Markel Products; a division of TPI Corporation.
      4. QMark Electric Heating; a division of Marley Engineered Products.
   C. Comply with UL 499 and UL 2021.
   D. Enclosures: Aluminized or Stainless-steel housing with anodized-aluminum reflector.
      1. Finish: Baked-enamel finish in manufacturer's custom paint color as selected by Architect.
   E. Unit Controls:
      1. Line-voltage thermostat.
      2. Enclosed contactor for remote thermostat.

2.2 PREFABRICATED ELECTRIC RADIANT HEATING PANELS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Berko Electric Heating; a division of Marley Engineered Products.
      2. Markel Products; a division of TPI Corporation.
      3. QMark Electric Heating; a division of Marley Engineered Products.
B. Description: Sheet-metal-enclosed panel with heating element suitable for lay-in installation flush with T-bar ceiling grid or recessed mounting. Comply with UL 2021.
   1. Panel: Minimum 0.0276-inch- (0.7-mm-) thick, galvanized-steel sheet back panel riveted to minimum 0.0396-inch- (1.0-mm-) thick, galvanized-steel sheet front panel with fused-on crystalline surface.
   2. Heating Element: Powdered graphite sandwiched between sheets of electric insulation.
   4. Electrical Connections: Nonheating, high-temperature, insulated-copper leads, factory connected to heating element.
   7. Exposed-Side Panel Finish: Baked-enamel finish in manufacturer's custom paint color as selected by Architect.
   8. Surface-Mounting Trim: Sheet metal with baked-enamel finish in manufacturer's custom paint color as selected by Architect.

C. Wall Thermostat: Bimetal, sensing elements calibrated from 55 to 90 deg F (13 to 32 deg C); with contacts suitable for low-voltage circuit, and manually operated on-off switch with contactors, relays, and control transformers.

D. Capacities and Characteristics: Refer to Drawings.

2.3 HYDRONIC HEATING PANELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Airtite.
   2. Airtext

B. Description: Modular or Linear sheet metal panel with serpentine water piping, suitable for lay-in installation flush with T-bar ceiling grid or recessed mounting.
   1. Panels: Minimum 0.115 inch- thick, aluminum sheet.
   2. Backing Insulation: Minimum 1-inch-thick, mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB with factory-applied jacket.
   3. Exposed-Side Panel Finish: Provide as scheduled on the Plans. If not indicated, select from the following options:
      a. Apply silk-screened finish to match appearance of Architect-selected acoustical ceiling tiles.
      b. Baked-enamel finish in manufacturer's custom paint color as selected by Architect.
   4. Factory Piping: ASTM B 88, Type M (ASTM B 88M, Type C) copper tube with ASME B16.22 wrought-copper fittings and brazed joints. Piping shall be mechanically bonded to panel.
5. The linear radiant ceiling panel shall consist of 0.115 inch thick extruded fluted linear aluminum faceplate. The extruded sections shall have tongue and grooved panel edges with steel channel cross braces attached by mechanical fastener. Copper tubes (0.569 inch I.D.) shall be mechanically attached to the aluminum faceplate by using a saddle/top cap strip on each extruded section which encapsulates the copper tube. Furnish blank filler pieces at corners and other locations shown or required to form a continuous line. Panels will be field cut, mitered, and installed to conform with architectural features of the ceiling and panel layout shown on Drawings. Each 18 inch wide panel shall have 4 tubes. Special - the edge of the panel which is against the window shall have a straight extruded edge, not tongue and groove.

6. Performance Requirements:
   a. The radiant ceiling panels shall produce a minimum of 204 BTU/HR/SQ.FT. at 190 degrees F mean water temperature, specified heating output when the average unheated surface temperature is 70 degrees F with a 70 degree air temperature. Ratings will be accepted only from an independent test laboratory.
   b. The maximum water pressure drop shall be in accordance with the following schedule (for 24 inch x 24 inch panels):

| Flow GPM of Water per 100 ft. Tube |
|----------|----------|
| 2.0      | 3.00     |
| 1.5      | 2.00     |
| 1.0      | 1.00     |

7. Performance Requirements:
   a. As scheduled on Drawings.

8. Surface-Mounting Trim: Sheet metal with baked-enamel finish in manufacturer's custom paint color as selected by Architect.

9. Accessories:
   a. 6 or 8-inch panel with drape track recess.
   b. 5-inch (127-mm) male bullnose panel.
   c. 5-inch (127-mm) female bullnose panel.
   d. 4-inch (102-mm) male corner panel.
   e. 4-inch (102-mm) female corner panel.
   f. Inside corner panel.
   g. 1/2-inch (13-mm) filler panel.

C. Characteristics: Refer to Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine areas to receive radiant heating units for compliance with requirements for installation tolerances and other conditions affecting performance.
B. Examine roughing-in for hydronic piping and/or electrical connections to verify actual locations before radiant heating unit installation.
C. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION
   A. Install radiant heating units level and plumb.
   B. Suspend radiant heaters from structure.
   C. Support for Radiant Heating Panels in or on Grid-Type Suspended Ceilings: Use grid as a support element.
      1. Install a minimum of four ceiling support system rods or wires for each panel. Locate not more than 6 inches (150 mm) from panel corners.
      2. Support Clips: Fasten to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
      3. Panels of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support panels independently with at least two 3/4-inch (19-mm) metal channels spanning and secured to ceiling tees.
      4. Install at least one independent support rod or wire from structure to a tab on panel. Wire or rod shall have breaking strength of the weight of panel at a safety factor of 3.
   D. Verify locations of thermostats with Drawings and room details before installation.

3.3 CONNECTIONS
   A. Piping installation requirements are specified in Division 23 Section "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
   B. Unless otherwise indicated, install shutoff valve and union or flange at each connection.
   C. Install piping adjacent to unit to allow service and maintenance.
   D. Ground electric units according to Division 26 Section "Grounding and Bonding."
   E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL
   A. Testing: Perform the following field tests and inspections and prepare test reports:
      1. Operate electric heating elements through each stage to verify proper operation and electrical connections.
      2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and units.
   B. Remove and replace malfunctioning units and retest as specified above.
   C. After installing panels, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

3.5 DEMONSTRATION
   A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain radiant heaters and panels. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238213
SECTION 238219 - FAN COIL UNITS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes fan coil units and accessories.

1.2 DEFINITIONS
A. BAS: Building Automation System.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
C. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Ceiling suspension components.
   2. Structural members to which fan-coil units will be attached.
   3. Method of attaching hangers to building structure.
   4. Size and location of initial access modules for acoustical tile.
   5. Items penetrating finished ceiling, including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
   6. Perimeter moldings for exposed or partially exposed cabinets.
D. Samples:
   1. Samples for Initial Selection: For units with factory-applied color finishes.

1.5 INFORMATIONAL SUBMITTALS
A. Field Quality Control Test Reports.
1.6 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For fan-coil units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
      1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.
      2. Special Warranty Information: Special warranty specified in this Section.

1.7 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.8 COORDINATION
   A. Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.9 EXTRA MATERIALS
   A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      1. Fan-Coil-Unit Filters: Furnish one (1) spare filters for each filter installed.
      2. Fan Belts: Furnish one (1) spare fan belts for each unit installed.

PART 2 - PRODUCTS

2.1 FAN-COIL UNITS
   A. Manufacturers:
      1. Airtherm; a Mestek Company.
      2. Environmental Technologies, Inc.
      5. Trane.
      6. USA Coil & Air.
      7. YORK International Corporation.

   B. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

   C. Coil Section Insulation: 1-inch (25-mm) thick, foil-covered, closed-cell foam complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
      1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.

   D. Main and Auxiliary Drain Pans: Stainless steel formed to slope from all directions to the drain connection as required by ASHRAE 62.1-2007. Drain pans shall be removable.

   E. Chassis: Galvanized steel with flanged edges. Floor-mounting units shall have leveling screws.
F. Cabinet: Construct of minimum 18-ga steel with baked-enamel finish in manufacturer's custom paint color as selected by Architect.
   1. Vertical Unit Front Panels: Removable, steel, with steel discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
   2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with cast-aluminum discharge grilles.
   3. Steel recessing flanges for recessing fan-coil units into ceiling or wall.

G. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   1. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.

H. Hydronic Coils: Construct of 5/8 O.D. 0.025 inch thick seamless copper tubes mechanically bonded to 0.010 inch thick plate type aluminum fins. Design for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve. Provide same end connection for supply and return.

I. Fan and Motor Board: Removable.
   1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Galvanized-steel wheels and galvanized-steel fan scrolls.
   2. Motor: Multispeed "ECM" Motor shall be provided. Factory calibrated FPB for optimum unit efficiency for operating CFM per schedule on drawing. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   3. Wiring Termination: Connect motor to chassis wiring with plug connection.

J. Control devices and operational sequences are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

K. Electrical Connection: Factory wire motors and controls for a single electrical connection.

2.2 DUCTED FAN-COIL UNITS

   1. Environmental Technologies, Inc.
   4. Trane.
   5. USA Coil & Air.
   6. YORK International Corporation.

B. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

C. Coil Section Insulation: 1-inch (25-mm) thick foil-faced glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
   1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.

D. Drain Pans: Stainless steel formed to slope from all directions to the drain connection as required by ASHRAE 62.1-2007.

E. Chassis: Galvanized steel with flanged edges, baked-enamel finish and removable access panels.
F. Cabinets: Construct of minimum 18-ga steel with baked-enamel finish in manufacturer's standard paint color.
   1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis with mill-finish, aluminum, double-deflection grille.
   2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
   3. Mixing Plenum: Sheet metal plenum finished and insulated to match the chassis with outdoor- and return-air, formed-steel dampers.
   4. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.

G. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   1. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.

H. Hydronic Coils: Construct of 5/8 O.D. 0.025 inch thick seamless copper tubes mechanically bonded to 0.010 inch thick plate type aluminum fins. Design for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve. Provide same end connection for supply and return.

I. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and brazed joints at fittings. Comply with ARI 210/240, and leak test to minimum 450 psig (3105 kPa) for a minimum 300-psig (2070-kPa) working pressure. Include thermal expansion valve.

J. Direct-Driven Fans (Fan motor less than 5HP total): Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

K. Belt-Driven Fans (Fan motor 5HP or greater): Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the cabinet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
   1. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

L. Remote condensing units are specified in Division 23 Section "Packaged Compressor and Condenser Units."

M. Control devices and operational sequence are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

N. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION
   A. Install fan-coil units level and plumb.
   B. Install fan-coil units to comply with NFPA 90A.
   C. Suspend fan-coil units from structure with vibration isolators and restraints specified in Division 23 Section "Vibration Controls for HVAC."
   D. Protect units with protective covers during balance of construction.
   E. Install new filters in each fan-coil unit within two (2) weeks after Substantial Completion.

3.3 CONNECTIONS
   A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
      1. Install piping adjacent to machine to allow service and maintenance.
      2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
      3. Connect condensate drain to indirect waste.
         a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.
   B. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23 Section "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.
   C. Ground equipment according to Division 26 Section "Grounding and Bonding."
   D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL
   A. Perform the following field tests and inspections and prepare test reports:
      1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
      2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
      3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
   B. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING
   A. Adjust initial temperature and humidity set points.
   B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

END OF SECTION 238219
SECTION 238239 – HEATING TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY
   A. Section Includes:
      1. Cabinet Heaters.
      2. Unit Heaters.
      4. Finned Tube Radiation.
      5. Convectors.
     10. Wall Heaters - Electric.

1.2 DEFINITIONS
   A. BAS: Building automation system.
   B. CWP: Cold working pressure.
   C. PTFE: Polytetrafluoroethylene plastic.
   D. TFE: Tetrafluoroethylene plastic.

1.3 SUBMITTALS
   A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS
   A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.
   B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
      1. Layout Drawings: Plans, elevations, sections, and details.
      2. Location and size of each field connection.
      3. Details of anchorages and attachments to structure and to supported equipment.
      4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.
      5. Location and arrangement of piping valves and specialties.
   C. Samples:
      1. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.
      2. Samples for Verification: Finish colors for each type of cabinet unit heater and wall and ceiling heaters indicated with factory-applied color finishes.

HEATING TERMINAL UNITS 238239 - 1

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1.5 INFORMATIONAL SUBMITTALS
   A. Field Quality Control Test Reports.

1.6 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For heating terminal units to include in emergency operation and maintenance manuals.

1.7 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   B. I=B=R Compliance: Test and rate baseboard and finned tube radiation in accordance with I=B=R, provide published ratings bearing emblem of I=B=R.
   C. ARI Compliance: Provide coil ratings in accordance with ARI Standard 410 "Forced Circulation Air Cooling and Air Heating Coils".
   D. ASHRAE Compliance: Test coils in accordance with ASHRAE Standard 33 "Methods of Testing Forced Circulation Air Cooling and Heating Coils".
   E. AMCA Compliance: Air curtains shall be tested in accordance with AMCA, Standard 220, "Test Methods for Air Curtains", and shall be licensed to bear the AMCA Certified Ratings Seal.

1.8 EXTRA MATERIALS
   A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      1. Heating Terminal Unit Filters: Furnish one spare filter for each filter installed.

PART 2 - PRODUCTS

2.1 CABINET HEATERS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Airtherm.
      2. Berko.
      3. Indeeco.
      4. Markel.
      5. McQuay.
      6. QMark.
      7. Rittling.
      8. Trane.
      9. USA Coil & Air.
   B. Description: A factory-assembled and -tested unit complying with ARI 440.
   C. Coil Section Insulation: ASTM C 1071; surfaces exposed to airstream shall be aluminum-foil facing to prevent erosion of glass fibers.
      1. Thickness: 1 inch (25 mm).
2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F (0.037 W/m x K at 24 deg C) mean temperature.
3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.

D. Cabinet: Steel with baked-enamel finish with manufacturer's custom paint, in color selected by Architect.
   1. Vertical Unit, Exposed Front Panels: 16 gage thick, galvanized, sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
   2. Horizontal Unit, Exposed Bottom Panels: Minimum 18 gage thick, galvanized, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
   3. Recessing Flanges: Steel, finished to match cabinet.
   4. Control Access Door: Key operated.
   5. Provide access door on coil connection side.
   6. Base: Minimum 16 gage thick steel, finished to match cabinet, 4 inches (100 mm) high with leveling bolts.
   7. Extended Piping Compartment: 8-inch- (200-mm-) wide piping end pocket.
   9. Outdoor-Air Wall Box: Minimum 16 gage thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen. Aluminum louver with anodized finish in color selected by Architect from manufacturer's custom colors.
      a. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with electronic, two-position actuators.

E. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   1. Pleated, MERV 7.

F. Hot-Water Coil: Construct of 5/8 O.D. 0.025 inch thick seamless copper tubes mechanically bonded to 0.010 inch thick plate type aluminum fins. Design for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve. Provide same end connection for supply and return.

G. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection, limit controls for high-temperature protection, and two stage heating. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware. Must be UL approved.

H. Fan and Motor Board: Removable.
   1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
   2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

I. Control devices and operational sequences are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

J. Electrical Connection: Factory wire motors and controls for a single field connection.
2.2 UNIT HEATERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Airtherm.
2. Engineered Air.
3. McQuay.
4. Rittling.
5. Trane.

B. Description: An assembly including casing, coil, fan, and motor in vertical or horizontal discharge configuration with adjustable discharge louvers.

C. Comply with UL 2021.

D. Comply with UL 823.

E. Cabinet: Removable panels for maintenance access to controls.

F. Cabinet Finish: Manufacturer's standard baked enamel applied to factory-assembled and tested propeller unit heater before shipping.

G. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

H. General Coil Requirements: Test and rate hot-water propeller unit heater coils according to ASHRAE 33.

I. Hot-Water Coil: Construct of 5/8 O.D. 0.025 inch thick seamless copper tubes mechanically bonded to 0.010 inch thick plate type aluminum fins. Design for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 325 deg F (163 deg C), with manual air vent. Test for leaks to 350 psig (2413 kPa) underwater.

J. Electric-Resistance Heating Elements: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch (4 mm). Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F (288 deg C) at any point during normal operation.

2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

K. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

L. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Motor Type: Permanently lubricated, multispeed.

M. Control Devices and Operational Sequences are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

2.3 BASEBOARD RADIATION

A. General: Provide baseboard radiation of lengths and in locations as indicated, and of capacities, style, and having accessories as scheduled.
B. Enclosures: Minimum 16 gauge cold-rolled steel, one-piece back and top panel, front panel with integral damper. Provide steel brackets, inserted in back/top panel, to support element and front panel. Provide baked enamel finish, standard colors.

C. Elements: Copper tube and aluminum fins, with slide mechanism between element and support brackets to eliminate expansion and contraction noises.

D. Accessories: Provide the following accessories:
   1. Bland end caps.
   2. End caps with hinged access panel.
   3. Trim strips.

E. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
   1. Slant/Fin Corp.
   2. Sterling Radiator.
   3. Trane (The) Co.
   4. Rittling.

2.4 FINNED TUBE RADIATION

A. General: Provide finned tube radiation of lengths and in locations as indicated, and of capacities, style, and having accessories as indicated on the drawing.

B. Enclosures: Minimum 1 gauge cold-rolled steel full backplate, minimum 16 gauge front. Brace and reinforce front minimum of 4'-0" o.c. without visible fasteners.

C. Elements: Copper tube and aluminum fins, with tube mechanically expanded into fin collars to eliminate noise and ensure durability and performance at scheduled ratings.

D. Finish: Flat black heat resisting paint for backplate; factory-finished baked enamel, standard colors, on fronts and accessories.

E. Accessories:
   1. End panels, inside and outside corners, and enclosure extensions.
   2. Access panels in front of valves, balancing cocks, and traps.
   3. Factory mounted dampers.
   4. Sill extensions.
   5. Mullion channels.
   6. Pilaster covers.

F. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
   1. Slant/Fin Corp.
   2. Sterling Fin-Tube Radiator Corp.
   3. Trane (The) Co.
   4. Rittling.

2.5 CONVECTORS

A. General: Provide convector  having cabinet sizes and in locations as indicated, and of capacities, style, and having accessories as indicated on the Drawings.
B. Cabinets: Minimum 16 gauge steel front and top panels, 18 gauge side panels, and 20 gauge back panels. Phosphatize and galvanize back panels, phosphatize and paint tops, sides, and fronts, with one coat of primer and baked enamel finish, standard colors. Secure fronts in place with quick opening slide bolts or camlock fasteners.
   1. Recessed Cabinets: One-piece front panel, with 4-side gasketed overlap.

C. Elements: Aluminum fins, ribbed steel side plates, fin tube supports and copper tubes, cast-iron headers. Factory-test each element to 150 psi air pressure under water.

D. Accessories: Provide the following accessories:
   1. Factory-mounted dampers.
   2. 1/2 inch insulation on cabinet back.
   3. Access doors in front for valve access.

E. Manufacturer: Subject to compliance with requirements, provide convectors of one of the following:
   2. Sterling.
   3. Trane (The) Co.

2.6 COILS

A. General: Provide coils of size and in location indicated, and of capacities and having performance data as scheduled. Certify coil capacities, pressure drops, and selection procedures in accordance with ARI 410.

B. Heating Coils:
   1. Fins: Construct of 0.010 inch thick continuous aluminum or copper configured plate-fin type with full fin collars for accurate spacing and maximum fin-tube contact.
   2. Tubes: Construct of 5/8 inch O.D., 0.025 inch thick seamless copper tubing, expanded into fin collars for permanent fin-tube bond and expanded into header for permanent leaktight joint.
   3. Headers: Construct of gray cast iron for coils 33 inches high and smaller. Hydrostatically test to 400 psi before assembly. Construct of round seamless copper tube for coils over 33 inches high.
   4. Casings: Construct of 16 gauge continuous coated galvanized steel with fins recessed into channels to minimize air bypass.
   5. Testing: Proof test coils at 300 psi, leak test at 200 psi under water.
   6. Coil Types: Provide the following coil types as indicated, and as scheduled.

C. Manufacturer: Subject to compliance with requirements, provide coils of one of the following:
   1. Aerofin Corp.
   2. McQuay, Inc.
   3. Trane (The) Co.
2.7 COILS - ELECTRIC, DUCT-MOUNTED
A. General: Provide coils of size and in location indicated, and of capacities and having performance data as schedule.
B. Construction - Four-sided double flange, aluminized steel terminal box with hinged cover. 80 percent nickel, 20 percent chromium type A coiled resistance wire encased in a grounded, finned tubular metal sheath rigidly supported.
C. Listing - UL listed for zero clearance to combustible surface and shall meet the requirements of the latest National Electrical Code.
D. Installation - Per UL listing and National Electrical Code.
E. Controls - Automatic reset and manual reset thermal cutouts, air flow switch, control transformer, terminal blocks, non-fused disconnect, staging contactors, two stages. Controls to be integrateable with DDC system.
F. Size, Capacity, Circuits, etc. - As shown on Drawings.
G. Special - Must fit space allocated.
H. Manufacturers subject to compliance with requirements, provide coils of one of the following:
   1. Berko.
   2. Indeeco.
   3. Markel.

2.8 RADIANT CEILING PANELS - ELECTRIC
A. Type - Low surface temperature rated at 375 watts. Unit shall be recessed for lay-in ceilings or surface mounted with flange option for plaster ceilings, approximately 24 inches square. Unit to be UL listed.
B. Finish - Repaintable latex paint, color as selected by Architect.
C. Accessories - Wall mounted line voltage control thermostat.
D. Electrical - Voltage and phase as shown on Drawings.
E. Controls – Provide interlock with Building Automation System for control by outside air temperature.
F. Manufacturer: Subject to compliance with requirements, provide electric radiant ceiling panels of one of the following:
   1. Q Mark, A division of Markel.

2.9 RADIANT CEILING PANELS - HOT WATER
A. General: Provide radiant system of size and in location indicated, and of capacities and having performance data as scheduled. Submit certified capacities, pressure drops, and selection procedures.
B. Provide complete extruded linear radiant panel ceiling system as shown on drawing in all areas, as scheduled and detailed on the drawings and as herein specified.
C. The linear radiant ceiling panel shall consist of 0.115 inch thick extruded fluted linear aluminum faceplate. The extruded sections shall have tongue and grooved panel edges with steel channel cross braces attached by mechanical fastener. Copper tubes (0.569 inch I.D.) shall be mechanically attached to the aluminum faceplate by using a saddle/top cap strip on each extruded section which encapsulates the copper tube. Furnish blank filler pieces at corners and other locations shown or required to form a continuous line. Panels will be field cut, mitered, and installed to conform with architectural features of the ceiling and panel layout shown on drawings. Each 18 inch wide panel shall have 4 tubes. Special - the edge of the panel which is against the window shall have a straight extruded edge, not tongue and groove.

D. Finish shall be powder coat, white.

E. Performance Requirements:
   1. The radiant ceiling panels shall produce a minimum of 204 BTU/HR/SQ.FT. at 190 degrees F mean water temperature, specified heating output when the average unheated surface temperature is 70 degrees F with a 70 degree air temperature. Ratings will be accepted only from an independent test laboratory.
   2. The maximum water pressure drop shall be in accordance with the following schedule (for 24 inch x 24 inch panels):

<table>
<thead>
<tr>
<th>Flow GPM of Water per 100 ft. Tube</th>
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<tbody>
<tr>
<td>2.0</td>
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<tr>
<td>1.5</td>
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<tr>
<td>1.0</td>
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<tr>
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<tr>
<td>Max. Pressure Drop Ft.</td>
</tr>
<tr>
<td>3.00</td>
</tr>
<tr>
<td>2.00</td>
</tr>
<tr>
<td>1.00</td>
</tr>
</tbody>
</table>

F. Installation - Refer to Section 3. Use turnbuckles in hanging wires to insure that the panel is installed tight against the window clip.

G. Provide 1-1/2 inch thick insulation with aluminum foil over face and edge over all panels.

H. Manufacturer: Subject to compliance with requirements, provide hot water radiant ceiling panels of one of the following:
   1. Aero Tech.
   2. Sun-El Corporation.

2.10 WALL HEATERS - ELECTRIC

A. Heavy duty, wall-mounted, forced air electric unit heater of wattage, voltage, capacity, type as scheduled on Drawings.

B. Enclosure - Minimum 1/16 inch thick louver bladed front attached to 16 gauge cabinet with tamperproof screws.

C. Motor - Totally enclosed, shaded-pole with impedance protection. Airflow shall be 245 cfm.

D. Electric Coil - Steel sheathed type elements of helically coiled nickel chromium alloy-resistant wire, enclosed in steel sheaths.

E. Control/Safeties: Manually reset zero voltage reset thermal overload that disconnects motor and elements; UL listed; integrally mounted thermostat covered by tamper resistant plate; contactors; built-in circuits breakers.

F. Manufacturer: Subject to compliance with requirements, provide coils of one of the following:
   1. Berko.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive heating terminal units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF CABINET HEATERS AND UNIT HEATERS

A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 07 Section "Joint Sealants."

B. Install cabinet and unit heaters as indicated and in accordance with manufacturer's installation instructions.

C. Install units level and plumb.

D. Suspend cabinet and unit heaters from structure with all-thread hanger rods and vibration isolators and restraints specified in Division 23 Section "Vibration Controls for HVAC."

E. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with drawings and room details before installation.

F. Protect units with protective covers during balance of construction.

G. Install new filters in each unit within two (2) weeks of Substantial Completion.

3.3 INSTALLATION OF BASEBOARD RADIATION

A. General: Install baseboard radiation as indicated and in accordance with manufacturer's installation instructions.

B. Locate baseboard radiation on outside walls as indicated, run cover continuous wall-to-wall unless otherwise indicated.

C. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window.

D. Install end caps where units butt against walls. Install access panels centered in front of each shutoff valve, balancing cock, or temperature control valve.

3.4 INSTALLATION OF FINNED TUBE RADIATION

A. General: Install finned tube radiation as indicated and in accordance with manufacturer's installation instructions.

B. Locate finned tube radiation on outside walls as indicated, run cover wall-to-wall unless otherwise indicated.

HEATING TERMINAL UNITS
C. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window.

D. Install end caps where units butt against walls. Install access panels centered in front of each shut-off valve, balancing valve or temperature control valve.

3.5 INSTALLATION OF CONVECTORS
   A. General: Install convectors as indicated and in accordance with manufacturer’s installation instructions.
   B. Locate convectors as indicated, coordinate with other trades to assure correct recess size for recessed convectors.

3.6 INSTALLATION OF COILS
   A. General: Install coils as indicated, and in accordance with manufacturer's installation instructions.
   B. Provide for each hot water coil unit, water supply, return connection, strainer, shut-off valves, automatic temperature regulating valve, balancing cocks, as indicated.

3.7 INSTALLATION OF COILS - ELECTRIC, DUCT MOUNTED
   A. General: Install coils as indicated and in accordance with manufacturer’s installation instructions.

3.8 INSTALLATION OF RADIANT HEATING PANELS - ELECTRIC
   A. Install where indicated on drawings in accordance with manufacturer’s instruction and Division 26 electrical requirements.

3.9 INSTALLATION OF RADIANT HEATING PANELS - HOT WATER
   A. All work under this Specification will be installed by the Contractor's radiant panel installer. The Contractor's radiant panel installer shall have three (3) years of experience and shall have installed at least five (5) projects of a similar size in the last three (3) years.
   B. The Contractor's radiant panel installer must supply a detailed piping layout to show panel circuiting.
   C. Install all panels in accordance with the manufacturer’s recommendation.
   D. If interferences occur, before installing any of the work in question, the Contractor’s radiant ceiling panel installer shall consult with other trades and shall come to an agreement with them as to the exact location and level of piping, ductwork, electrical work and/or other parts of their equipment.
   E. Wall channels and support angles required to frame the ceiling openings will be provided and installed by other Divisions. The ceiling openings shall provide for necessary expansion and contraction of the ceiling panels. The Contractor's radiant ceiling installer shall install in finished openings and provide all necessary support steel and panel support channels, including turnbuckles to draw the panels tight to the window clip.
   F. All interconnecting fittings of radiant panels shall be full size of pipe 0.625 inch O.D. and furnished with the panels and installed by the Contractor’s radiant panel installer.
G. All interconnecting piping between the supply and return points shall be jointed and tested by
the Contractor's radiant panel installer. Each group of panels shall be given a pressure test in
accordance with procedures specified in Division 23. No loss in pressure shall occur during the
test. All points shall be leak tested with the joint under test pressure.

H. Supply and return piping, runouts, valves, dielectric waterway fittings, and air vents shall be
provided by Division 23.

I. The panel interconnection pipe and bends shall be full pipe size and furnished by the panel
manufacturer and shall provide for necessary expansion and contraction of the panel system,
and assembled with 95-5 tin-antimony solder as recommended by the manufacturer.

J. All system piping shall be thoroughly cleaned, flushed, drained and refilled before radiant panels
are connected into the system.

K. The Contractor's radiant panel installer shall furnish and install 1-1/2 inch thickness fiberglass
batt insulation with aluminum face above all active radiant panels. Care shall be taken to
assure that return air openings are not blocked by the insulation, however, panels shall be
completely covered.

3.10 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate
general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect supply and return ducts to cabinet heaters with flexible duct connectors specified in
Division 23 Section "Air Duct Accessories."

D. Comply with safety requirements in UL 1995.

E. Unless otherwise indicated, install union and shutoff valve on supply-water connection and
union and balancing valve, and shutoff on return-water connection of heating terminal units.
Hydronic specialties are specified in Division 23 Section "Hydronic Piping."

F. Unless otherwise indicated, install union and shutoff valve on steam-supply connection and
union, strainer, steam trap, and shutoff valve on condensate-return connection of heating
terminal units. Steam specialties are specified in Division 23 Section "Steam and Condensate
Heating Piping."

G. Ground equipment according to Division 26 Section "Grounding and Bonding."

H. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and
Cables."

I. General: Install electrical devices furnished by manufacturer but not specified to be factory
mounted. Furnish copies of manufacturer's wiring diagram submittal to electrical installer.
Verify that electrical wiring installation is in accordance with manufacturer's submittal and
installation requirements of Division 26 sections. Do not proceed with equipment start-up until
wiring installation is acceptable to equipment installer.

3.11 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm
proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.

3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

3.12 ADJUSTING AND CLEANING

A. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.

B. Retouch any marred or scratched surfaces of factory finished cabinets, using finish materials furnished by manufacturer.

C. Install new filter units for terminals requiring same.

3.13 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heating terminal units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238239
SECTION 238313 - RADIANT-HEATING ELECTRIC CABLES

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes electric heating cables for ceiling or floor radiant heating, snow and ice melting on pavement, and freezer-floor frost-heave prevention with the following electric heating cables:
1. Mineral insulated, series resistance.

1.2 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS
A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
1. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.
B. Shop Drawings: For electric heating cable. Include plans, sections, details, and attachments to other work.
C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Items installed in finished ceiling, including the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
   f. Perimeter moldings.

1.4 INFORMATIONAL SUBMITTALS
A. Field Quality Control Test Reports.

1.5 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.
1. Special Warranty Information: Special warranty specified in this Section.
1.6 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.7 COORDINATION
   A. Coordinate layout and installation of electric heating cables and system components with other construction.
      1. Coordinate concrete, reinforcement, and formwork with requirements specified in Division 03.
      2. Coordinate with ceiling and/or floor installation requirements.
      3. Coordinate with roofing installer for installation and roof penetrations specified in Division 07 Sections.
      4. Coordinate with freezer installer for cable placement in subsoil below insulation for freezer specified in Division 11 Section "Foodservice Equipment."

1.8 WARRANTY
   A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.
      1. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MINERAL-INSULATED, SERIES-RESISTANCE HEATING CABLES
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Delta-Therm Corporation.
      2. Raychem; a division of Tyco Thermal Controls.
      3. Watts Radiant, Inc.
   B. Heating Element: Single- or dual-conductor resistor wire. Terminate with waterproof, factory-assembled nonheating leads with connectors at both ends.
   C. Electrical Insulating Mineral: Magnesium oxide.
   D. Cable Cover: Copper/nickel alloy and high-density polyethylene outer jacket.
   E. Maximum Operating Temperature: 300 deg F (150 deg C).
   F. Capacities and Characteristics: Refer to Drawings.

2.2 PLASTIC-INSULATED, SERIES-RESISTANCE HEATING CABLES
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Raychem; a division of Tyco Thermal Controls.
      2. Watts Radiant, Inc.
   B. Comply with UL 1673.
C. Heating Element: Single- or dual-stranded resistor wire. Terminate with waterproof, factory-assembled nonheating leads with connectors at both ends.

D. Electrical Insulating Jacket: Minimum 4.0-mil (0.10-mm) Kapton with silicone jacket or Tefzel.

E. Cable Cover: Aluminum braid and silicone or Hylar outer jacket.

F. Maximum Operating Temperature: 300 deg F (150 deg C).

G. Capacities and Characteristics: Refer to Drawings.

2.3 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Chromalox, Inc.; Wiegard Industrial Division; Emerson Electric Company.
   2. Raychem; a division of Tyco Thermal Controls.

B. Comply with UL 1673.

C. Heating Element: Pair of parallel No. 16 AWG, nickel-coated stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

D. Electrical Insulating Jacket: Flame-retardant polyolefin.

E. Cable Cover: Stainless-steel braid, and polyolefin outer jacket with UV inhibitor.

F. Maximum Operating Temperature (Power On): 150 deg F (65 deg C).

G. Maximum Operating Temperature: 300 deg F (150 deg C).

H. Capacities and Characteristics: Refer to Drawings.

2.4 CONTROLS

A. Refer to Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

B. Wall-Mounting Thermostats for Ceiling and Floor Heating Cables:
   1. Minimum temperature range from 50 to 90 deg F (10 to 32 deg C).
   2. Manually operated with on-off switch.

C. Precipitation and Temperature Sensor for Snow Melting on Pavement:
   2. Precipitation and temperature sensors shall sense the surface conditions of pavement and shall be programmed to energize the cable as follows:
      a. Temperature Span: 34 to 44 deg F (1 to 7 deg C).
      b. Adjustable Delay Off Span: 30 to 90 minutes.
      c. Energize Cables: Following two-minute delay if ambient temperature is below set point and precipitation is detected.
   3. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
4. Minimum 30-A contactor to energize cable or close other contactors.
5. Precipitation sensor shall be mounted in pavement.
6. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control system workstation.

2.5 ACCESSORIES
A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.
   1. Ensure surfaces in contact with electric heating cables are free of burrs and sharp protrusions.
   2. Ensure surfaces and substrates are level and plumb.
   3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS
A. Install the following types of electric heating cable for the applications described:

3.3 INSTALLATION
A. Install electric heating cable or mats across expansion, construction, and control joints according to manufacturer's written recommendations using cable protection conduit and slack cable to allow movement without damage to cable.
B. Do not energize cables embedded in concrete or plaster until those assemblies are cured.
C. Electric Heating Cable Installation for Ceiling Radiant Heating: Install heating cable with heat-conductive fill materials such as plaster, to ensure direct contact with finished radiant surfaces.
D. Electric Heating Cable Installation for Floor Radiant Heating: Install heating cable with heat-conductive fill materials such as concrete, to ensure direct contact with finished radiant surfaces.
E. Electric Heating Cable Installation for Snow and Ice Melting on Pavement:
   1. Install heating cable with heat-conductive fill materials such as asphalt or concrete, to ensure direct contact with finished radiant surfaces.
   2. Install cables or mats after applying bituminous binder course to lower base; ensure that second bituminous binder course is applied to cables before pouring finish topping.
F. Electric Heating Cable Installation for Freezer-Floor Frost-Heave Prevention: Install electric heating cable below insulation in subsoil.

G. Set field-adjustable switches and circuit-breaker trip ranges.

H. Protect installed heating cables, including nonheating leads, from damage.

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
   1. Test cables for electrical continuity and insulation integrity before energizing.
   2. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying finished surface on heating cables.

C. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 238313
SECTION 238316 - RADIANT-HEATING HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes radiant heating piping, including pipes, fittings, and piping specialties.

1.2 DEFINITIONS
A. EPDM: Ethylene-propylene-diene terpolymer rubber.
B. PEX: Crosslinked polyethylene.
C. PEX/AL/PEX: Crosslinked polyethylene/aluminum/crosslinked polyethylene.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: For each type of radiant heating pipe, fitting, manifold, specialty, and control.
   1. For radiant heating piping and manifolds, include pressure and temperature rating, oxygen-barrier performance, fire-performance characteristics, and water flow and pressure drop characteristics.
B. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.
   1. Shop Drawing Scale: 1/4 inch = 1 foot (1:50).
C. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which radiant heating piping will be attached.
   3. Items penetrating finished ceiling, including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
   4. Perimeter moldings.

1.5 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For radiant heating piping valves and equipment to include in operation and maintenance manuals.
PART 2 - PRODUCTS

2.1 PEX PIPE AND FITTINGS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Slant/Fin Corp.
2. Stadler-Viega.
3. Uponor Wirsbo Co.
5. Zurn Plumbing Products Group.

C. Pipe Material: PEX plastic according to ASTM F 876.

D. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.

E. Fittings: ASTM F 1807, metal insert and copper crimp rings.

F. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 180 deg F (82 deg C).

2.2 PEX/AL/PEX PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. IPEX Inc.
2. Stadler-Viega.
3. Uponor Wirsbo Co.

B. Pipe Material: PEX plastic bonded to the inside and outside of a welded aluminum tube according to ASTM F 1281.

C. Oxygen Barrier: Limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.

D. Fittings: ASTM F 1974, metal insert fittings with split ring and compression nut (compression joint) or metal insert fittings with copper crimp rings (crimp joint).

E. Flame-Spread and Smoke-Developed Indexes: 25 and 50 or less, respectively, tested according to ASTM E 84.

F. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 210 deg F (99 deg C).

2.3 EPDM PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Watts Radiant, Inc.; a division of Watts Water Technologies, Inc.

B. Pipe Material: Crosslinked EPDM inner and outer tubes.

C. Wall Thickness: Minimum 0.125 inch (3.2 mm).
D. Oxygen Barrier: Ductile aluminum foil layer applied to the inner tube to limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.

E. Reinforcing Braid: Braided-aluminum wire between the inner and outer tube.

F. Fittings: ASTM F 1807, copper with stainless-steel crimps or clamps.

G. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 210 deg F (99 deg C).

2.4 DISTRIBUTION MANIFOLDS

A. Manifold: Minimum NPS 1 (DN 25), brass or stainless steel.

B. Main Shutoff Valves:
   1. Factory installed on supply and return connections.
   2. Two-piece body.
   3. Body: Brass or bronze.
   4. Ball: Stainless steel. Chrome plated balls are not acceptable.
   5. Seals: PTFE.
   6. CWP Rating: 150 psig (1035 kPa).

C. Manual Air Vents:
   1. Body: Bronze.
   2. Internal Parts: Nonferrous.
   3. Operator: Key furnished with valve, or screwdriver bit.
   4. Inlet Connection: NPS 1/2 (DN 15).
   5. Discharge Connection: NPS 1/8 (DN 6).
   6. CWP Rating: 150 psig (1035 kPa).

D. Balancing Valves:
   1. Body: Bronze, ball or globe cartridge type.
   2. Ball or Plug: Stainless steel.
   4. Seat: PTFE.
   7. Handle Style: Lever or knob, with memory stop to retain set position if used for shutoff.
   8. CWP Rating: Minimum 125 psig (860 kPa).

E. Zone Control Valves:
   1. Body: Bronze, ball or plug, or globe cartridge type.
   2. Ball or Plug: Stainless steel.
   4. Seat: PTFE.
   5. Actuator: Replaceable electric motor.
   7. Maximum Operating Temperature: 250 deg F (121 deg C).
F. Thermometers:
   1. Mount on supply and return connections.
   2. Case: Dry type, metal, 2-inch (50-mm) diameter.
   3. Element: Bourdon tube or other type of pressure element.
   4. Movement: Mechanical, connecting element and pointer.
   9. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem.
   10. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

G. Mounting Brackets: Copper, or plastic or copper-clad steel, where in contact with manifold.

2.5 PIPING SPECIALTIES

A. Cable Ties:
   1. Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
   2. Minimum Width: 1/8 inch (3 mm).
   3. Tensile Strength: 20 lb (9 kg), minimum.
   4. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

B. Floor-Mounting Staples:
   1. Steel, with corrosion-resistant coating and smooth finish without sharp edges.
   2. Minimum Thickness: 3/32 inch (2.4 mm).
   3. Width: Minimum, wider than tubing.

C. Floor-Mounting Clamps:
   1. Two bolt, steel, with corrosion-resistant coating and smooth finish without sharp edges.
   2. Minimum Thickness: 3/32 inch (2.4 mm).
   3. Width: Minimum, wider than tubing.

D. Floor Mounting Tracks:
   1. Aluminum or plastic channel track with smooth finish, no sharp edges.
   2. Minimum Thickness: 1/16 inch (1.6 mm).
   3. Slot Width: Snap fit to hold tubing.
   4. Slot Spacing: 2-inch (50-mm) intervals.

E. Modular Interlocking Blocks:
   1. Polypropylene snap-together blocks with grooves to support piping.
   2. Galvanized sheet metal or aluminum emission plates.
   3. Natural mineral board cover panel.

F. Heat-Emission Plates:
   1. Formed aluminum suitable for radiant heating piping.
   2. Minimum Thickness: 1/16 inch (1.6 mm).
   3. Slot Width: Snap fit to maintain pressure fit on tubing.
2.6 CONTROLS

A. Temperature-control devices and sequence of operations are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Honeywell.
2. REHAU.
3. Slant/Fin Corp.
4. Stadler-Viega.
5. Tekmar Control Systems, Ltd.
6. Uponor Wirsbo Co.
7. Watts Radiant, Inc.; a division of Watts Water Technologies, Inc.

C. Wall-Mounting Thermostat:
1. Minimum temperature range from 50 to 90 deg F (10 to 32 deg C).
2. Manually operated with on-off switch.
3. Day and night setback and clock program with minimum four periods per day.
4. Operate pumps or open zone control valves if room temperature falls below the thermostat setting, and stop pumps or close zone control valves when room temperature rises above the thermostat setting.

D. Heated-Panel Thermostat:
1. Remote bulb unit with adjustable temperature range from 50 to 90 deg F (10 to 32 deg C).
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump or zone control valve.
3. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant panel temperature.
4. Stop pump or close zone control valves if heated-panel thermostat setting is exceeded.
5. Corrosion-resistant, waterproof control enclosure.

E. Heated-Panel Thermostat with Outdoor Temperature Reset:
1. Remote bulb unit with adjustable temperature range from 50 to 90 deg F (10 to 32 deg C).
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump and zone control valve.
3. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant panel temperature.
4. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing outdoor-air temperature.
5. Operate zone control valves to reset supply-water temperature inversely with outdoor-air temperature.
6. Corrosion-resistant, waterproof control enclosure.

F. Precipitation and Temperature Sensor:
2. Precipitation and temperature sensors shall sense the surface conditions of pavement and shall be programmed to operate pump and zone control valves as follows:
   a. Temperature Span: 34 to 44 deg F (1 to 7 deg C).
b. Adjustable Delay Off Span: 30 to 90 minutes.
c. Start Pump or Open Zone Control Valves: Following two-minute delay if ambient temperature is below set point and precipitation is detected.
d. Stop Pump or Close Zone Control Valves: On detection of a dry surface plus time delay.

3. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
4. Minimum 30-A contactor to start pump and open valves.
5. Precipitation sensor shall be mounted in pavement.
6. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control system workstation.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine surfaces and substrates to receive radiant heating piping for compliance with requirements for installation tolerances and other conditions affecting performance.
1. Ensure that surfaces and pipes in contact with radiant heating piping are free of burrs and sharp protrusions.
2. Ensure that surfaces and substrates are level and plumb.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS
A. Install the following types of radiant heating piping for the applications described:
1. Piping in Exterior Pavement: EPDM or PEX/AL/PEX.
2. Piping in Interior Reinforced-Concrete Floors: PEX.
3. Piping in Level Fill Concrete Floors (Not Reinforced): PEX.
4. Piping in Ceilings: EPDM, PEX or PEX/AL/PEX.
5. Piping in Subfloors: EPDM, PEX or PEX/AL/PEX.

3.3 INSTALLATION
A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop or Coordination Drawings.
B. Install radiant heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.
C. Connect radiant piping to manifold in a reverse-return arrangement.
D. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.
E. Install manifolds in accessible locations, or install access panels to provide maintenance access as required in Division 08 Section "Access Doors and Frames."
F. Refer to Division 23 Section "Hydronic Piping" for pipes and connections to hydronic systems and for glycol-solution fill requirements.
G. Fire- and Smoke-BARRIER Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials according to Division 07 Section "Penetration Firestopping."

H. Piping in Exterior Pavement:
1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
2. Space cable ties a maximum of 18 inches (457 mm) o.c., and at center of turns or bends.
3. Maintain 3-inch (75-mm) minimum cover.
4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
5. Maintain minimum 40-psig (275-kPa) pressure in piping during concrete placement and continue for 24 hours after placement.

I. Piping in Interior Reinforced-Concrete Floors:
1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
2. Space cable ties a maximum of 18 inches (457 mm) o.c., and at center of turns or bends.
3. Maintain 2-inch (50-mm) minimum cover.
4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
5. Maintain minimum 40-psig (275-kPa) pressure in piping during concrete placement and continue for 24 hours after placement.

J. Piping in Level Fill Concrete Floors (Not Reinforced):
1. Secure piping in concrete floors by attaching pipes to subfloor using tracks, clamps, or staples.
2. Space tracks, clamps, or staples a maximum of 18 inches (457 mm) o.c., and at center of turns or bends.
3. Maintain 3/4-inch (19-mm) minimum cover.
4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
5. Maintain minimum 40-psig (275-kPa) pressure in piping during the concrete pour and continue for 24 hours during curing.

K. Piping in Ceiling:
1. Secure piping by attaching pipes to ceiling substrate using clamps or staples.
2. Space clamps or staples a maximum of 18 inches (457 mm) o.c., and at center of turns or bends.
3. Maintain 1-1/2-inch (38-mm) minimum plaster cover.
4. Maintain minimum 40-psig (275-kPa) pressure in piping during the plaster application and continue for 24 hours during curing.

L. Piping in Subfloor:
1. Secure piping by laying piping in subfloor channels or modular interlocking blocks.
2. Use straight channel panels or blocks in the center, and curved channel panels or blocks at the ends.
3. Finish floor with mineral board panel cover or finished floor surface.
M. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.

N. After system balancing has been completed, mark balancing valves to permanently indicate final position.

O. Perform the following adjustments before operating the system:
   1. Open valves to fully open position.
   2. Check operation of automatic valves.
   3. Set temperature controls so all zones call for full flow.
   4. Purge air from piping.

P. After the concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant heating system as follows:
   1. Start system heating at a maximum of 10 deg F (6 deg C) above the ambient radiant panel temperature, and increase 10 deg F (6 deg C) each following day until design temperature is achieved.
   2. For freeze protection, operate at a maximum of 60 deg F (16 deg C) supply-water temperature.

3.4 FIELD QUALITY CONTROL

A. Prepare radiant heating piping for testing as follows:
   1. Open all isolation valves and close bypass valves.
   2. Open and verify operation of zone control valves.
   3. Flush with clean water, and clean strainers.

B. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig (690 kPa). Repair leaks and retest until no leaks exist.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning radiant heating piping components that do not pass tests, and retest as specified above.

D. Prepare a written report of testing.

END OF SECTION 238316
SECTION 238413 - HUMIDIFIERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following humidifiers:
   1. Steam dispersion panel humidifiers.
   2. Steam-to-steam humidifiers.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 23 Section "Basic Division 23 Requirements."

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, manifolds, and attachments to other work.

C. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Structural members to which humidifiers will be attached.
   2. Size and location of initial access modules for acoustical tile.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For humidifiers to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with ARI 640, "Commercial and Industrial Humidifiers."

1.7 COORDINATION

A. Coordinate location and installation of humidifiers with manifolds in ducts and air-handling units or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.
PART 2 - PRODUCTS

2.1 DUCT MOUNTED STEAM DISPERSION PANEL HUMIDIFIERS (PRESSURIZED STEAM WITH ATMOSPHERIC CONDENSATE)

A. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:
   1. Dri-Steem Corporation.
   3. Nortec Industries Inc.

B. The steam dispersion panel shall be duct mounted and shall directly inject 5 psi minimum pressurized clean steam from a clean steam generator with RO/DI makeup water feed system or a low pressure boiler house steam system into ducted air for humidification.

C. Steam dispersion panel:
   1. Provide insulated steam supply header and insulated condensate collection header.
   2. Provide closely-spaced steam dispersion tubes spanning the distance between the supply header (the top portion of the assembly frame) and the bottom condensate collection header.
      a. Dispersion tubes shall be insulated with a plenum-approved insulating material for in-duct installation and have an R-value not less than 0.5 at a thickness not more than 0.125”.
      b. Insulating material shall have the following characteristics:
         1) Fire/smoke index of 0/0 per test procedures according to:
            a) UL 723 fire/smoke index (Test for Surface Burning Characteristics of Building Materials).
            b) NFPA 255 (Standard Method of Test of Surface Burning Characteristics of Building Materials).
            c) AASTM E84 (Surface Burning Characteristics for Materials Used in Plenums).
         2) Stable up to 300 °F continuous to prevent material degradation, hardening, or crumbling at high temperatures.
         3) Closed-cell construction that does not absorb water or support microbial growth to negate the need for vapor barriers and jackets.
         4) Non-toxic and pure as documented in manufacturer's data to prevent off-gassing and to facilitate use in clean rooms, pharmaceutical applications, and food industries.
         5) No degradation when exposed to UVC light to negate the need for UV wraps.
         6) Continuous, seam-welded construction, and shall be held in place without bands or clamps to minimize surfaces for the accumulation of particulate matter.

   3. Each dispersion tube shall be fitted with two rows of steam discharge tubelets inserted into the tube wall, centered on the diametric line, and spaced 1.5” apart. Each tubelet shall be made of a thermal-resin material designed for high steam temperatures. The two rows of tubelets in each dispersion tube shall discharge steam in diametrically opposite directions, perpendicular to airflow.

   4. Each tubelet shall extend through the wall of and into the center of the dispersion tube and contain a steam orifice sized for its required steam capacity.
5. Humidifier panel assembly of tubes and headers shall be contained within a stainless steel metal casing to allow convenient duct mounting, or to facilitate the stacking of and/or the end-to-end mounting of multiple humidifier panels in ducts or air handler casings. When so designated, the humidifier panel shall be shipped unassembled.

6. Tubes and headers shall be 304 stainless steel, and welded joints shall be Heli-arc welded.

7. Tubes shall be gasketed and slip coupled to ensure a tight seal to the supply header and to facilitate easy removal.

D. Steam trap(s): Provide humidifier with two inverted bucket traps and associated inlet strainers. Steam traps shall be sized for a minimum of 3 times the maximum rated condensate flow of humidifier at 1/2-psig inlet pressure.

E. Stainless Steel Construction: Entire assembly and all appurtenances including but not limited to casing assembly, dispersion panel tubes, panel grid headers, control valve, strainers and traps shall be 304 stainless steel.

F. Control Valves:
   1. Provide modulating all stainless steel electronic humidification steam control valve. Valve shall be a normally closed modulating type with an electronic actuator. Actuator shall respond to a variable electronic signal of 0 to 10 VDC.
   2. The valve shall utilize a parabolic plug design with immediate response and precise, equal percentage, modulation of flow with a 3/4" minimum valve stroke. Valve shall have an 80:1 minimum rangeability per ANSI/ISA recognized test procedures. Valve shall be ANSI Class 250 with ANSI Class IV shut-off and rated for 15 psig minimum pressure drop.
   3. Valve shall be selected for 2 psig pressure drop at design steam flow.
   4. Valve and actuator shall be as manufactured by Baumann or approved equal.

   1. Unless noted otherwise on the Drawings, the humidifier shall provide 15” maximum absorption distance.

H. Accessories:
   1. Duct-mounted, high-limit humidity sensor suitable for VAV applications to anticipate air flow changes and reset accordingly.
   2. In-line strainers.
   3. Airflow switch to prevent humidifier operation without airflow suitable for VAV applications. Airflow proving switch shall be operational between 250 FPM and 1,500 FPM and based on a pressure control. “Sail type” airflow proving devices are not allowed.
   4. Drain Cooler: Provide a thermostatically controlled water valve which shall meter an amount of cold water into a stainless steel mixing chamber to temper 212 deg. F (100 deg. C) water with a 6 gpm (0.38 L/s) in-flow rate to a 140 deg. F (60 deg. C) discharge temperature to sanitary system.

I. Provide welded 304 stainless steel piping and appurtenances for clean steam and condensate applications.
2.2 STEAM-TO-STEAM HUMIDIFIERS (ATMOSPHERIC STEAM)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Dri-Steem Corporation.
   3. Nortec Industries Inc.

B. Heat Exchanger and Evaporation Tank: Construct with ASTM A 666, Type 304 stainless steel with corrosion-resistant coating, overflow, and drain fittings.
   1. Factory Insulation: Cover entire humidifier with 1” thick (25 mm) rigid, foil-faced fiberglass insulation. All surfaces except front face panel shall have insulation.

C. Manifold: ASTM A 666, Type 304 stainless-steel, duct-mounting, single- or manifold-grid piped rigidly to steam generator and extending across width of duct or plenum. Manifold shall have mounting brackets for both ends.

D. Controls:
   1. Solenoid-fill and automatic drain valves to maintain water level and temper hot drain water.
   2. Field-adjustable timer to control drain cycle for flush duration and interval.
   3. Float-type level controls.

E. Accessories:
   1. Humidistat: Wall or return-duct-mounting, solid-state, electronic-sensor controller capable of full modulation.
   2. Duct-mounting, high-limit humidistat.
   3. Airflow switch for preventing humidifier operation without airflow.

F. Capacities and Characteristics: As scheduled on the Drawings.

2.3 DUCT MOUNTED STEAM DISPERSION PANEL HUMIDIFIERS (PRESSURIZED STEAM/CONDENSATE RECOVERY)

A. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:
   1. Dri-Steem Corporation.
   3. Nortec Industries Inc.

B. The steam dispersion panel shall be duct mounted and shall directly inject 5 psi minimum pressurized clean steam from a clean steam generator with RO/DI makeup water feed system or a low pressure boiler house steam system into ducted air for humidification.

C. Steam Dispersion Panel:
   1. Steam supply header/separater with integral condensate heat exchanger that provides condensate vaporizing and pressurized condensate return.
      a. All dispersion tube-generated condensate that falls to the heat exchanger in the header shall be vaporized into humidification steam.
      b. As condensate is vaporized in the header, pressurized condensate created in the heat exchanger shall return to main without additional pumps, valves or controls.
2. Provide closely-spaced steam dispersion tubes spanning the distance between the supply header (the top portion of the assembly frame) and the bottom condensate collection header.
   a. Dispersion tubes shall be insulated with a plenum-approved insulating material for in-duct installation and have an R-value not less than 0.5 at a thickness not more than 0.125".
   b. Insulating material shall have the following characteristics:
      1) Fire/smoke index of 0/0 per test procedures according to:
         a) UL 723 fire/smoke index (Test for Surface Burning Characteristics of Building Materials).
         b) NFPA 255 (Standard Method of Test of Surface Burning Characteristics of Building Materials).
         c) AASTM E84 (Surface Burning Characteristics for Materials Used in Plenums).
      2) Stable up to 300 °F continuous to prevent material degradation, hardening, or crumbling at high temperatures.
      3) Closed-cell construction that does not absorb water or support microbial growth to negate the need for vapor barriers and jackets.
      4) Non-toxic and pure as documented in manufacturer's data to prevent off-gassing and to facilitate use in clean rooms, pharmaceutical applications, and food industries.
      5) No degradation when exposed to UVC light to negate the need for UV wraps.
      6) Continuous, seam-welded construction, and shall be held in place without bands or clamps to minimize surfaces for the accumulation of particulate matter.

3. Each dispersion tube shall be fitted with two rows of steam discharge tubelets inserted into the tube wall, centered on the diametric line, and spaced 1.5" apart. Each tubelet shall be made of a thermal-resin material designed for high steam temperatures. The two rows of tubelets in each dispersion tube shall discharge steam in diametrically opposite directions, perpendicular to airflow.

4. Each tubelet shall extend through the wall of and into the center of the dispersion tube and contain a steam orifice sized for its required steam capacity.

5. Humidifier panel assembly of tubes and headers shall be contained within a stainless steel metal casing to allow convenient duct mounting, or to facilitate the stacking of and/or the end-to-end mounting of multiple humidifier panels in ducts or air handler casings. When so designated, the humidifier panel shall be shipped unassembled.

6. Tubes and headers shall be 304 stainless steel, and welded joints shall be Heli-arc welded.

7. Tubes shall be gasketed and slip coupled to ensure a tight seal to the supply header and to facilitate easy removal.

D. Steam Trap(s): Provide humidifier with two inverted bucket traps and associated inlet strainers. Steam traps shall be sized for a minimum of 3 times the maximum rated condensate flow of humidifier at 1/2-psig inlet pressure.

E. Stainless Steel Construction: Entire assembly and all appurtenances including but not limited to casing assembly, dispersion panel tubes, panel grid headers, control valve, strainers and traps shall be 304 stainless steel.
F. Control Valves:
   1. Provide modulating all stainless steel electronic humidification steam control valve. Valve shall be a normally closed modulating type with an electronic actuator. Actuator shall respond to a variable electronic signal of 0 to 10 VDC.
   2. The valve shall utilize a parabolic plug design with immediate response and precise, equal percentage, modulation of flow with a 3/4" minimum valve stroke. Valve shall have an 80:1 minimum rangeability per ANSI/ISA recognized test procedures. Valve shall be ANSI Class 250 with ANSI Class IV shut-off and rated for 15 psig minimum pressure drop.
   3. Valve shall be selected for 2 psig pressure drop at design steam flow.
   4. Valve and actuator shall be as manufactured by Baumann or approved equal.
   5. Heat Exchanger Steam Valve and Actuator: Valve shall be a two position, normally closed, solenoid operated, on-off steam valve. Valve shall respond to a signal from a compatible humidistat.

   1. Unless noted otherwise on the Drawings, the humidifier shall provide 15" maximum absorption distance.

H. Accessories:
   1. Duct-mounted, high-limit humidity sensor suitable for VAV applications to anticipate air flow changes and reset accordingly.
   2. In-line strainers.
   3. Airflow switch to prevent humidifier operation without airflow suitable for VAV applications. Airflow proving switch shall be operational between 250 FPM and 1,500 FPM and based on a pressure control. "Sail type" airflow proving devices are not allowed.
   4. Drain Cooler: Provide a thermostatically controlled water valve which shall meter an amount of cold water into a stainless steel mixing chamber to temper 212 deg. F (100 deg. C) water with a 6 gpm (0.38 L/s) in-flow rate to a 140 deg. F (60 deg. C) discharge temperature to sanitary system.

I. Provide welded 304 stainless steel piping and appurtenances for clean steam and condensate applications.

J. Time Delay Relay: Heat exchanger shall remain on after no call for humidity to evacuate all condensate for a period of time not less than 5 minutes, adjustable up to 100 minutes.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
   B. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.
   C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
   A. Install humidifiers with required clearance for service and maintenance.
   B. Seal humidifier manifold duct or plenum penetrations with flange.
C. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

D. Install stainless steel duct with 2” deep drain pan around each manifold mounted in ducts.
   1. Construct drain pans to comply with ASHRAE 62.
   2. Extend stainless steel duct and drain pan minimum 12” upstream and minimum 24” downstream from manifold.

E. Install manifold supply piping pitched to drain condensate back to humidifier.

F. Install drip leg upstream from steam trap a minimum of 12 inches (300 mm) tall for proper operation of trap.

G. Install steam generator level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results for HVAC."

H. Concrete Bases: Anchor steam generator to concrete base.
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported equipment.
   5. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
   1. Install piping adjacent to humidifiers to allow service and maintenance.
   2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.

B. Provide welded 304 stainless steel steam and condensate piping and steam and condensate appurtenances for clean steam and condensate.

C. Install electrical devices and piping specialties furnished by manufacturer but not factory mounted.

D. Install piping from safety relief valves to nearest floor drain.

E. Ground equipment according to Division 26 Section "Grounding and Bonding."

F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

G. Install instrumentation and control systems according to Division 23 "Instrumentation and Control for HVAC."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
B. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain humidifiers. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238413
SECTION 260010 - BASIC DIVISION 26 REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general administrative, material, and procedural requirements for Division 26 to expand the requirements specified in Division 01.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Permits and Inspections:

1. Permits: Obtain and pay for all permits, bonds, licenses, tap-in fees, etc., required by the City, State, or other authority having jurisdiction over the work, as a part of the work of the affected sections.

2. Inspections: Arrange and pay for all inspections required by the above when they become due as part of the work of the sections affected. Conceal no work until approved by these governing authorities. Coordinate inspection period with Authorities Having Jurisdiction and Engineer through Construction Manager. Present the Engineer with properly signed certificate of final inspection.

B. Coordination:

1. Coordinate facility services as outlined in Division 20 Section "Common Work Results, Division 21 through 28."

2. Coordinate arrangement, mounting, and support of Division 26 equipment:

   a. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.

   b. To provide for ease of disconnecting the equipment with minimum interference to other installations.

   c. To allow right of way for piping and conduit installed at required slope.

   d. To assure connections of raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

3. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

4. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

   a. Ensure access doors are sized to permit complete access for concealed or inaccessible junction boxes, control and monitoring devices, elevator shaft and duct mounted fire alarm detectors and other items of equipment requiring access, maintenance, and/or operation.

      1) Ensure access to devices per codes and local authorities having jurisdiction.

5. Coordinate equipment furnished by Division 26: Install and wire in accordance with the manufacturer’s recommendations and applicable standards and codes. Provide installation instructions, locating dimensions and wiring diagrams for the other trades. Supervise the installation and start-up and test the equipment unless otherwise specified.
6. Coordinate Equipment Furnished by Other Divisions: Equipment specified in other Divisions and requiring electrical supply will be erected, aligned, leveled and prepared for operation. Provide required controls and accessories along with installation instructions, diagrams, dimensions and supervision of installation and start-up. Provide the required electrical rough-ins and confirm the electrical controls and accessories furnished under the specifications for the other divisions. Install those controls and accessories not located in the mechanical piping and ductwork. Provide additional electrical controls, accessories, fittings and devices not specified under the equipment but required for a finished, operating job. Make final electrical connections. Participate in the start-up and test services.

1.3 SUBMITTAL PROCEDURES
A. General: Provide required submittals in accordance with Division 01 "Submittal Procedures".
B. Definitions:
   1. Submittals: A written or graphic expression of the Contractor’s interpretation of requirements in the Contract Documents to show how the Contractor intends to fulfill those requirements. Identify deviations from Contract Documents.
   2. Action Submittals: Required submittal which Engineer reviews and approves or takes other appropriate action to communicate to the Contractor the status if the submittal and subsequent action required.
   3. Other (Information, Closeout and Maintenance and Material) Submittals: Required submittals which Engineer reviews and may elect to respond. If rejected by Engineer for not complying with requirements, resubmittal or other action may be required on the part of the Contractor.
C. Failure to Submit:
   1. Contractor’s failure to provide submittals does not alleviate the responsibility to provide the requirements in the Contract Document as interpreted by the Engineer. Correct non-compliant items.
D. Applicable Information:
   1. All information not applicable to the project shall be crossed out in the submittal. All applicable accessories, options, etc., shall be clearly indicated. Failure to comply shall be grounds for the submittal to be rejected.

1.4 ACTION SUBMITTALS
A. Submit action submittals in groups by systems. For example, all lighting fixtures, lamps, ballasts and accessories shall be submitted simultaneously in one package.
B. Submit the following action submittals as qualified in associated Division 26 Sections:
   1. Back to back recessed box or cabinet installation locations list.
   2. Batteries and battery chargers (submit with associated system).
   3. Box fittings approved for use with healthcare facilities MC cables.
   4. Conduit fittings.
   5. Contactors.
   6. Control/Signal transmission media (submit with associated system).
   7. Control voltage electrical power cables (may be submitted with associated system).
8. Dimming systems.
9. Disconnect switches.
10. Electric power management systems.
11. Electrical identification.
12. Hangers and supports.
13. Isolated power systems.
14. Lighting.
15. Lighting control equipment.
16. Lightning protection systems.
17. Medium voltage cable, terminations, and splices.
18. Motor controllers.
20. Multi-service boxes and assemblies.
22. Protective device coordination.
23. Protective devices.
26. Switchgear.
27. Transfer switches (automatic and/or manual).
28. Transformers.
29. Underfloor ducts.
30. Underground ducts.
31. Uninterruptible power supplies.
32. Unit substations.
33. Vibration controls.
34. Wire guards.
35. Wiring devices.

C. Action submittals submitted for other than those listed above or specifically required in the appropriate Specification Section will not be reviewed or returned.

D. Contractor Certificates:
   1. Contractor certification forms may be submitted in accordance with Division 01 Section "Submittal Procedures" in lieu of system action submittal product data requirements except for the systems or products listed below:
      a. Dimming systems.
      b. Electric power management systems.
      c. Isolated power systems.
      d. Lightning protection systems.
      e. Luminaire and lighting systems.
      f. Lighting control systems.
      g. Protective devices.
      h. Switchgear.
      i. Transfer switches.
      j. Transformers.
      k. UPS systems.
      l. Disconnect switches.
      m. Medium voltage cable.
1. Motor controllers.
2. Multi-service boxes and assemblies.
3. Panelboards.
4. Protective device coordination.
5. Surface raceways.
7. Underfloor ducts.
8. Unit substations.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Submit general coordination drawings in accordance with Division 01 Section "Project Management Coordination," to a scale of 1/4"=1'-0" or larger; detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

   a. Indicate the proposed locations of major raceway systems, equipment, and materials. Include the following:
      1) Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
      2) Exterior wall and foundation penetrations.
      3) Wall and floor sleeve penetrations.
      4) Floor box and poke-through assembly installations.
      5) Equipment connections and support details.
      6) Sizes and location of required concrete pads and bases.

   b. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

   c. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.

   d. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, luminaires, communications systems components, sprinklers, and other ceiling-mounted devices.

2. Submit the following specific coordination drawings and others as defined in other Division 26 Sections:

   a. Access door locations and sizes (as specified in Division 08).
   b. Building Cable Entry Rooms and Vaults.
   c. Communication Rooms.
   d. Electrical Equipment Rooms.
   e. Feeder Routings.
   f. Mechanical Equipment Rooms.
   g. Underfloor Duct Systems.
   h. Medical imaging/diagnostic procedure rooms.

BASIC DIVISION 26 REQUIREMENTS
1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. Prepare and submit operations and maintenance manuals in accordance with Division 01 Sections "Operation and Maintenance Data" and "Closeout Procedures". In addition to the requirements specified in Division 01, include specific Division 26 Section requirements, and the following general information for equipment items:

   a. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

   b. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

   c. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

   d. Servicing instructions and lubrication charts and schedules.

2. Include the following minimum information in the operations and maintenance manual:

   a. Individual characteristics for trouble shooting sequences for each item of each:

      1) Branch Circuit Panel.
      2) Distribution Panel.
      3) Fire Alarm System.
      4) Individual Motor Controller.
      5) Switchgear Assembly.
      6) Transformer.
      7) Unit Substation.
      8) Transfer switch.

   b. Catalog cut sheets for every item for which a shop drawing is required.

   c. Schedule of loads served from each:

      1) Branch Circuit Panel.
      2) Distribution Panel.
      3) Emergency Generator Control System.
      4) Switchgear Assembly.
      5) Transfer Switch.
      6) Unit Substation.
      7) Refer to Division 26 Section “PANELBOARDS” for schedule organization and format.

   d. On-hand spare parts list and complete parts list for each:

      1) Distribution Panel.
      2) Individual Motor Controller.
      3) Switchgear Assembly.
      4) Unit Substation.

   e. Tap setting schedule for each:

      1) Transformer.
f. Overload element schedule for each motor controller whether individual or in a motor control center.
g. Bolt tightening torques and inspection intervals on each:
   1) Bolted bus connection.
   2) Cable connection.
   3) Miscellaneous bolted electrical connections.
h. Manufacturers' recommended cleaning intervals and special procedures for each:
   1) Cooling fins.
   2) Dry-type transformer coil assembly.
   3) Electrical equipment interior.
   4) Electrical equipment ventilation opening.
   5) Luminaire lenses, louvers, and reflectors.
i. Main and arcing contact adjustment and replacement for each:
   1) Contactor.
   2) Circuit breaker.
   3) Fused switch.
   4) Interrupter switch.
   5) Motor controller.
   6) Transfer switch.
j. Calibration and exercise procedures and intervals for each:
   1) Air circuit breaker.
   2) Control system.
   3) Emergency battery ballast.
   4) Insulated case breaker.
   5) Molded case breaker.
   6) Relay.
   7) Transfer switch.
k. "As designed" and "as left" relay settings.
l. Testing interval and target values for ground fault protection circuit relays.
m. Testing and troubleshooting procedures unique to special systems. For example:
   1) Infrared scanning.
   2) Phase balancing.
   3) High-pot tests.
   4) Transformer tests.
   5) Voltage monitoring and adjustments of USS.

n. Approved special construction details that differ from the details shown on Drawings.
o. Permits and inspections certificates.
q. Final submittal copy.
r. Special warranty information.
s. Service contract data.
B. Record Documents:

1. Prepare record documents in accordance with the requirements in Division 01 Section “Project Closeout Procedures.” In addition to the requirements specified in Division 01, indicate installed conditions for:
   a. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
   b. Major equipment locations (exposed and concealed), dimensioned from prominent building lines.
   c. As built one line drawings.
   d. Final panel directories.
   e. Contract Modifications and actual equipment and materials installed.
   f. Training and demonstration videos.
   g. Keying schedules.
   h. Software CDs.
   i. Final field quality control test reports.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Material:

1. Provide four (4) keys for every different piece of electrical equipment which is equipped with a lock.
2. Provide all other loose equipment and extra material specified or supplied for use with all systems.

1.8 QUALITY ASSURANCE

A. General: Follow the procedures specified in Division 01 Section "Quality Requirements."

B. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.

C. Obtain similar products through one source from a single manufacturer.

D. Testing Agency Qualifications: An agency with the experience and capability to conduct the testing indicated and that is acceptable to authorities having jurisdiction.

1. For electrical power equipment and systems, the agency shall be a member company of the International Electrical Testing Association (NETA) or is a Nationally Recognized Testing Laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
2. For other than electrical power equipment or where NETA is not a recognized testing agent, the testing agency shall be as defined in the appropriate Division 26 section.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.
PART 2 - PRODUCTS

2.1 REGULATORY REQUIREMENTS

A. Work and materials shall conform to and be executed, inspected and tested in accordance with the latest edition of the National Electric Code and with the governing rules and regulations of federal, state and local governmental agencies. References to "NEC" within the Division 26 Sections shall be considered synonymous to this electrical code.

B. Other codes and standards which will apply to this installation include the current editions of:
   7. Underwriters Laboratories.

C. Where governing codes indicate the Drawings and Specifications do not comply with the minimum requirements of applicable codes, be responsible for either notifying the Architect in writing during the bidding period of the revisions required to meet code requirements, or providing an installation which will comply with the code requirements.

D. U.L. Listing
   1. All electrical equipment, products and materials shall bear the Underwriter’s Laboratories (UL), or other approved agency, listing label. Acceptable alternates include:
      b. Wherein an item of equipment is specified to be U.L. Listed, the entire assembly shall be listed by Underwriters Laboratories, Inc. Any modifications to suit the intent of the Specifications shall be performed in accordance with the National Electrical Code and listed by U.L.
   2. Definitions:
      a. Listed: Equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation, that maintain periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets appropriate designated standards or has been tested and found suitable for use in a specified manner.
      b. Labeled: Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by who’s labeling the manufacturer indicated compliance with appropriate standards or performance in a specified manner.

2.2 MATERIALS

A. Products and the terms materials, equipment, devices, components, assemblies and systems are considered synonymous.
B. All materials, unless otherwise specified, shall be new and be the standard products of the manufacturer. Seconds, rejects, or damaged materials will be rejected.

C. The materials to be provided under these Specifications shall be essentially the standard commercial grade product of the manufacturer. Where two or more units of the same class of equipment are required, these units shall be products of a single manufacturer.

D. The listing of a manufacturer for certain products does not indicate acceptance of a standard or catalogued item of equipment. All products shall conform to the Specifications.

E. All equipment and materials specified shall be products currently in production.
   1. If the specified item is not available or is discontinued, a similar product with the same features and functionality shall be provided from the same manufacturer in the newer/upgraded series of product.
   2. Equipment and/or devices discovered to be discontinued after submission approval will not be accepted and will require resubmittal for an approved replacement.

F. Product Selection for Restricted Space: Drawings indicated maximum dimensions for products including clearances between products and adjacent surfaces and other items. Comply with indicated maximum product dimensions.
   1. Assembly Selection: The Drawings indicated sizes, profiles and dimensional requirements of assembly equipment. Equipment having equal performance characteristics and complying with indicated maximum dimensions and profiles may be considered, provided deviations do not change the design concept intended performance, or code/future extension provision clearances. The burden of proof of equality is on the proposer a minimum of 10 days prior to bid.

G. Include the component parts thereof equipment such as disconnect switches, motor controllers, motors, drives, and guards necessary to the satisfactory and safe operation of the equipment.

2.3 SOFTWARE PROTECTION
A. All software supplied with new equipment shall be warranted against leap year program failure.
B. All software supplied with the new equipment shall be warranted against Daylight Savings Time program disruption or failure. Refer to Division 01 Section "Warranties and Supplementary Conditions for Requirements."
C. All software shall be the most current release of the latest available software of the equipment provided.
   1. BETA software versions will not be accepted.

PART 3 - EXECUTION

3.1 PREPARATION
A. General:
   1. Comply with NECA 1 – "Standard For Good Workmanship in Electrical Contracting."
   2. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
3. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

4. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

5. Right of Way: Give to piping systems installed at a required slope.

B. Manufacturer's Directions and Supervision:

1. Follow all instructions where supervision by a manufacturer is specified. Provide recommended manufacturer and specified field tests, and other recommendations of the manufacturer. The manufacturer shall supervise the installation, connection, start-up, testing, adjustment, instruction of the Owner and final tests of such equipment or system. Where two or more manufacturer's equipment are interrelated, take responsibility to coordinate their work and provide supervision.

2. Have the manufacturer instruct the Owner in the proper operation and maintenance techniques of all equipment, systems, etc., at the time of completion of all work.

C. Rough-In:

1. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

2. Refer to equipment specifications in Divisions 02 through 28 for rough-in requirements.

3.2 INSTALLATION

A. General:

1. Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment.

2. Workmanship shall conform to NECA 1 – "Standard for Good Workmanship in Electrical Contracting" published by the National Electrical Contractors Association.

B. Locations:

1. When Drawing details are not available, the Architect shall control the placement of wall and ceiling mounted electrical devices, luminaires and outlets. The intent is to aesthetically locate luminaires/outlets by providing rough-in hardware, boxes and/or mounting plates, as required, when stud or furring may not be readily available for direct mounting. Consult with Architect's representative for actual placement.

2. Coordinate electrical systems, equipment, and materials installation with other building components. Be responsible for any changes in openings and locations necessitated by the equipment installed.

3. Verify all dimensions by field measurements.

4. Install systems, materials, and equipment to provide the maximum headroom possible, where mounting heights are not detailed or dimensioned.
5. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.

6. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.

7. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

8. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

C. Field Coordination:

1. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.

2. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

3. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

4. Protect all equipment and materials from the elements, dirt and other damage from the time it is removed from the point of storage until final acceptance.

5. Include setting equipment to accurate line and grade, leveling equipment, aligning equipment components, providing and installing couplings, bolts, guards, and anchor bolts.

6. Align and level and meet the quality of workmanship subject to manufacturer's installation instructions.

7. Provide all trench and conduit excavation and backfilling required for his work inside and outside the building, including repairing of finished surfaces, all required shoring, bracing, pumping, and all protection for safety of persons and property. In addition, check the indicated elevations of the utilities entering and leaving the building. If such elevations require excavations lower than the footing levels, the Architect shall be notified of such conditions and a redesign shall be made before excavations are commenced. Make the excavations at the minimum required depths in order not to undercut the footings.

8. Provide all scaffolding, rigging, hoisting and services necessary for erection and delivery of equipment and apparatus furnished into the premises. These items shall be removed from the premises when no longer required.

9. No electrical equipment, raceways or other work of any kind shall be covered up or hidden from view before it has been examined and approved. Any unsatisfactory work or materials shall be removed and corrected immediately.

10. Coordinate installation of access panel or doors where units are concealed behind finished surfaces.

D. Excavation:

1. Slope sides of excavations to comply with local codes and ordinances. Shore and brace as required for stability of excavation.
2. Shoring and Bracing: Establish requirements for trench shoring and bracing to comply with local codes and authorities. Maintain shoring and bracing in excavations regardless of time period excavations will be open.
   a. Remove shoring and bracing when no longer required. Where sheeting is allowed to remain, cut to of sheeting at an elevation of 30 inches below finished grade elevation.

3. Install sediment and erosion control measures in accordance with local codes and ordinances.

4. Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and form flooding project site and surrounding area.
   a. Do not allow water to accumulate in excavations. Remove water to prevent softening of bearing materials. Provide and maintain dewatering system components necessary to convey water away from excavations.
   b. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey surface water to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.

5. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade and shape stockpiles for proper drainage.
   a. Locate and retain soil materials away from edge of excavations. Do not store within drip-line of trees indicated to remain.
   b. Remove and legally dispose of excess excavated materials and materials not acceptable for use as backfill or fill.

6. Trenching: Excavate trenches for electrical installations as follows:
   a. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches clearance on both sides of raceways and equipment.
   b. Excavate trenches to depth indicated or required.
   c. Limit the length of open trench to that in which installations can be made and the trench backfilled within the same day.
   d. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of raceways and equipment. Provide a minimum of 6 inches of stone or gravel cushion between rock bearing surface and electrical installations.

7. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35 deg. F (1 deg. C).

8. Backfilling and Filling: Place soil materials in layers to required subgrade elevations for each area classification listed below, using materials specified in Part 2 of this Section.
   a. Under walls and pavements, use a combination of subbase materials and excavated or borrowed materials.
   b. Under building slabs, use drainage fill materials.
   c. Under piping and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation.
d. For raceways less than 30 inches below surface of roadways, provide 4 inch thick concrete base slab support. After installation of raceways, provide a 4 inch thick concrete encasement (sides and top) prior to backfilling and placement of roadway subbase.

9. Refer to 260543 for other requirements on raceway encasement. Other areas use excavated or borrowed materials. Backfill excavations as promptly as work permits, but not until completion of the following:
   a. Inspection, testing, approval, and locations of underground utilities have been recorded.
   c. Removal of shoring and bracing and backfilling of voids.
   d. Removal of trash and debris.

10. Placement and Compaction: Place backfill and fill materials in layers of not more than 8 inches in loose depth for material compacted by heavy equipment and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

11. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification specified below. Do not place backfill or fill material on surfaces that are muddy, frozen or contain frost or ice.

12. Place backfill and fill materials evenly adjacent to structures, piping and equipment to required elevations. Prevent displacement of raceways and equipment by carrying material uniformly around them to approximately same elevation in each lift.

13. Compaction: Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below.
   a. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture density relationship (cohesive soils), determined in accordance with ASTM D 1557 and not less than the following percentages of relative density, determined in accordance with ASTM D 2049, for soils which will not exhibit a well-defined moisture density relationship (cohesionless soils).
      1) Areas Under Structures, Building Slabs and Steps, Pavements: Compact top 12 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
      2) Areas Under Walkways: Compact top 6 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
      3) Other Areas: Compact top 6 inches of subgrade and each layer of backfill or fill material to 85 percent maximum density for cohesive soils and 90 percent relative density for cohesionless soils.
   b. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water. Apply water in minimum quantity necessary to achieve required moisture content and to prevent water appearing on surface during, or subsequent to, compaction operations.
14. Subsidence: Where subsidence occurs at electrical installation excavations during the period 12 months after Substantial Completion, remove surface treatment (i.e. pavement, lawn, or other finish), add backfill material, compact to specified conditions and replace surface treatment. Restore appearance, qualify and condition of surface of finish to match adjacent areas.

E. Cutting and Patching:

1. General: Perform cutting and patching in accordance with Division 01 Section “Cutting and Patching” In addition to the requirements specified in Division 01, the following requirements apply:

a. Perform cutting, fitting, and patching of electrical equipment and materials required to:

   1) Uncover Work to provide for installation of ill-timed Work.
   2) Remove and replace defective Work.
   3) Remove and replace Work not conforming to requirements of the Contract Documents.
   4) Remove samples of installed Work as specified for testing.
   5) Install equipment and materials in existing structures.
   6) Upon written instructions from the Architect, uncover and restore Work to provide for Architect observation of concealed Work.

b. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.

c. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

d. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

e. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

f. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

   1) Refer to Division 01 Section "Quality Requirements" for definition of experience "Installer."

gh. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

   1) Refer to Division 01 Section "Quality Requirements" for definition of experienced "Installer."
F. Painting:

1. Provide the prime painting of all equipment and materials furnished under Division 26 specifications, unless specifically stated otherwise. In general, all equipment except raceways and galvanized boxes that are not provided with a factory-applied final finish shall be delivered to the job site with a shop applied prime coat of paint. Refer to Division 09 Sections "Interior Painting" and "Exterior Painting."

2. All manufacturers’ finished equipment surfaces damaged during construction shall be brought to an “as new” condition by touch up or repainting. Any rust shall be completely removed and the surface primed prior to repainting as specified in Division 09.

G. Owner Furnished Equipment

1. Refer to Division 01.

3.3 FIELD QUALITY CONTROL

A. Refer to Division 26 Section "Electrical Inspections and Testing."

3.4 ADJUSTING

A. Installation shall be walked with the Owner to verify access to all maintainable equipment is to the satisfaction of the Owner. Contractor shall be responsible for making changes and/or adjustments as necessary if access is determined to be insufficient.

B. Complete system programming to the satisfaction of the Owner. If, after preliminary use of the system or training, the increased understanding of the system’s features and capabilities necessitate programming or set-up adjustments, perform at no additional cost.

C. Provide software programming changes to match Owner’s final room number designations. The room numbers indicated on the Drawings are not necessarily the final room numbers and may be subject to change by the Owner.

D. Provide on-site assistance in reprogramming software-based system to suit actual occupied conditions during the warranty period. Provide up to three 8-hour visits to the site for this purpose.

END OF SECTION 260010
SECTION 260011 – SELECTIVE REMOVALS, RELOCATIONS, AND REARRANGEMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. The Drawings indicate renovated areas and identify those portions of buildings where renovation work shall be provided. Identified areas of buildings show electric work that shall be provided.

B. Removals, relocations and rearrangements shall be performed in all identified areas, as shown on Drawings.

C. The Contract Documents include D0800 series Demolition Drawings. These Demolition Drawings shall be interpreted as incomplete, and in general represent existing building electrical conditions.
   1. The Demolition Drawings included in the Contract Documents are not to be considered complete or accurate, and are included only to provide the general scope and extent of selective removals, relocations and rearrangements to be included. Visit the site prior to submitting the bid, to verify existing building conditions, in order to more accurately establish the removals, relocations and rearrangements required.
   2. The Demolition Drawings include description notes that provide an overall intent of removals, relocations and rearrangements.

D. Examine the existing structures and installations for the work of other trades which will influence the cost of the work on this project. The work shall include removals, relocations and rearrangements affecting the work of this Division as follows:
   1. Relating directly or incidental to the construction.
   2. The work of other Divisions which may interfere with, disturb, or complicate, the performance of the construction.
   3. Involving systems and/or equipment and relocated service lines which shall continue to be used or operated as part of the finished project.
   4. Luminaires, lamps, and ballasts.

E. Include in the base bid a dollar amount to provide the following scope of work associated with the survey, and determination of, the extent of removals required for this project:
   1. Survey existing fluorescent luminaires within the project spaces and work areas, scheduled for removals, for the purpose of determining whether or not PCB containing ballasts are present in existing luminaires, and whether or not the ballast(s) are leaking.
   2. Provide a non-destructive survey and investigation of existing fluorescent luminaires, including opening recessed troffer lens doors, temporarily removing lenses (on luminaires without lens doors), lamps, ballast covers, etc., in order to visually inspect and record luminaire ballast data.
   3. In any given room or space, where existing fluorescent luminaires are scheduled to be disconnected and removed, and potentially reinstalled, survey and inspect each luminaire for the purpose of determining whether or not a PCB containing ballasts exists, and whether or not it is leaking.
   4. Record the data for future action and provide copies of the data to the Owner and Architect.
PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 EXISTING CONDITIONS
A. Existing device locations have been identified as completely as possible by a site survey and by record documents as available. Be responsible for proper removal and rework of devices, equipment, and their associated work, not shown on Drawings to conform with intent of documents.

3.2 PREPARATION
A. General:
1. Disconnect electrical systems in walls, floors and ceiling scheduled for removal.
2. Coordinate utility outages with the Electric Utility Company and the Owner.
3. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operation.

B. Existing Electrical System: Maintain existing system in service until new systems are complete and ready for service. Disable system only to make switchovers and connections. Obtain permission from the Owner at least two weeks before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

C. Existing Fire Alarm System: Maintain existing system in service. Disable system only to make switchovers and connections. Notify the Owner and local fire service at least 72 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

3.3 GENERAL RENOVATION REQUIREMENTS
A. Remove all electric work presently installed on or in existing walls, ceilings and partitions which are to be demolished. Remove all exposed portions of wiring and raceways.

B. Remove all exposed raceways, exposed and concealed outlet boxes, etc. that are not to be reused where existing walls are to remain. Where new raceways and outlet boxes are shown on existing walls in finished rooms, they shall be installed concealed by cutting and patching method.

C. Reuse existing outlet boxes and raceway systems wherever practical in renovation areas. Install new wiring devices, coverplates, and wiring per applicable specification sections, where such existing outlet boxes are used. Special coverplates may be required to suit conditions.

D. Disconnect and remove, per NEC Articles 770 and 800, exposed feeder, branch circuit, remote control, power limited, non-power limited, and signal line system raceways and their associated circuits and wiring, including wiring for systems and equipment operating at 50 volts or less not installed in raceway rendered inoperable due to removals, relocations and rearrangements. This shall include the complete removal of wiring and cable abandoned by other Divisions, above or below ceilings, as part of this project.
E. Disconnect, remove, rework and otherwise rearrange existing raceways and wiring to accommodate new circuit arrangements indicated and/or required to maintain continuity of existing circuits feeding devices that are to remain.

F. Be responsible for removal and reinstallation of existing electrical equipment to accommodate the work of or disturbed by other trades.

G. In such cases where new circuit breakers or fusible switches are to be added to existing electrical distribution equipment, they shall be of the same manufacturer and design as the existing breakers or fusible switches with matching AIC ratings, except as otherwise noted, and shall be of the sizes as shown on Drawings.

1. Be responsible for rearranging any and all existing circuit breakers within the existing equipment, to facilitate the installation of new circuit breakers being added. Provide additional bus, bus extensions, bolts and hardware, enclosure modifications, directory modifications, etc., required to accomplish these modifications.

2. Provide new arc-fault signage per Division 26 Sections "Protective Device Coordination" and "Electrical Identification", where changes to the electrical distribution system alter or change the rating, hazard or safety requirements for the room, space, or area.

H. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide revised typed circuit directory showing revised circuiting arrangement.

3.4 SALVAGING

A. Stockpile removed, electrical equipment, devices, components, luminaires, etc. on job site, for reuse, until project closeout, unless specifically directed otherwise.

B. Legally remove items from site that the Owner does not wish to salvage.

3.5 LUMINAIRE REMOVALS

A. Disconnect, remove, and store, at the job site, in an indoor dry location, luminaires scheduled for reuse, that have been previously determined to not contain PCB fluorescent ballasts, until such time as they are ready to be reinstalled.

1. Existing lamps shall not be reused, regardless of whether or not the existing luminaire is scheduled for reuse. Existing lamps shall be legally disposed of, and reused luminaires shall be relamped with new lamps.

B. Remove luminaires that have been previously determined to not contain PCB fluorescent ballasts, and that are scheduled for disconnection and removal, and are not scheduled for reuse or reinstallation, to an on-site location, directed by the Owner. Removed luminaires shall remain the property of the Owner.

1. Remove lamps from luminaires, and store separately at an on-site location, directed by the Owner.

C. Remove from the site, and legally dispose of, disconnected and removed luminaires, that have been previously determined to not contain PCB fluorescent ballasts, and that the Owner does not wish to retain.

1. Remove lamps from luminaires and dispose of separately.
D. Do not use existing luminaires that have been determined to contain integral or remote mounted PCB fluorescent ballasts, either known, or determined by field survey and investigation.
   1. Disconnect and remove the PCB containing fluorescent ballast(s), if the ballast(s) is not leaking, per the ballast disposal requirements written herein, and replace with a new non-PCB replacement ballast.
   2. Notify the project Owner if the PCB containing ballast is leaking, and proceed no further. The luminaire is considered contaminated and hazardous. Removal of the luminaire shall be the responsibility of the Owner.

E. Do not remove or re-use existing luminaires installed in project spaces being abated for asbestos. Luminaires installed in project spaces being abated for asbestos shall be considered hazardous material, and as such shall be removed as part of the abatement process.

F. Do not remove existing luminaires installed in suspended, or other false ceiling spaces below known asbestos containing ceiling cavities. Luminaires installed in such ceiling spaces shall be considered hazardous material, and their removal shall be responsibility of the Owner.

3.6 LAMP DISPOSAL

A. Fluorescent, mercury vapor, metal halide, high pressure sodium, and neon lamps, contain some amount of the chemical mercury, and as such shall be handled as hazardous waste.

B. Lamp removal and disposal (both mercury containing and low-mercury types) shall be legally disposed of, in accordance with the requirements of the United States Environmental Protection Agency (USEPA) Universal Waste Rule (64 FR 36465-36490), and the state and local level project locale disposal requirements.

C. Remove lamps separately from their respective luminaires, and place (unbroken) into approved, labeled containers.
   1. Containers may be new cardboard boxes with cardboard lamp sleeves, or discarded cardboard boxes from new lamps with the lamp spacers left intact.

D. The total weight for all on-site, project related, disposed lamp containers, cannot exceed 500 lbs. at any one time. The containers shall be removed from the project site, delivered or picked-up by a licensed lamp recycler, and legally disposed of, within 1 year of lamp removal.

3.7 FLUORESCENT LAMP BALLAST DISPOSAL

A. Dispose of ballasts identified or labeled "NON-PCB", "NO PCB", or similar marking, (indicating that the ballast does not contain PCB), as ordinary construction waste.

B. Ballasts not identified or labeled "NON-PCB", "NO PCB", or similar marking (indicating that the ballast does not contain PCB), shall be presumed to be PCB containing, and shall be handled as hazardous waste.

C. Remove non-leaking ballasts containing PCB, or presumed to be containing PCB, from their respective luminaires.
   1. Provide protective gloves, eye protection, and protective clothing, for the person(s) removing ballasts.
   2. Place removed ballasts in contractor provided 55 or 30 gallon, US DOT approved, type 17C, or 17H drums (barrels). The quantity and size of the drums shall be determined by the Contractor.
3. Provide approved PCB absorbent materials placed and stored immediately adjacent to the drum storage area. Do not place loose absorbent material inside the drums.

4. Label and mark the PCB ballast storage drums with EPA approved PCB labels, and provide the appropriate warning signs, markings, and clearance lines, to meet the federal, state, and local hazardous materials handling regulations.

5. Place barrels containing removed PCB containing ballasts at an on-site, indoor storage location, sealed with the cover that came with the barrels. Barrels shall not be placed outside exposed to weather.

6. Provide to the Project representative, in written form, the total count of the ballasts removed (or their total weight by barrel), and where they are stored.

7. Barrels containing removed PCB ballasts shall not to be removed from the work site by the Contractor. To do so, would be a violation of DOT hazardous waste regulations and may result in a fine. Provide for the services of an authorized hazardous waste hauler to remove and deliver the ballasts to an authorized recycler, or PCB incinerator facility.

D. Do not remove ballasts containing PCB, or presumed to be containing PCB, that are visibly showing signs of leakage (evidenced by potting compound leakage or by an oily film on the ballast surface), from their respective luminaire. The entire luminaire shall be presumed to be contaminated, and shall be handled as a hazardous material.

1. Notify the project Owner, and proceed no further. Removal of the luminaire shall be the responsibility of the Owner.
SECTION 260505 – ELECTRICAL INSPECTIONS AND TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes electrical equipment and systems inspections and testing requirements for Division 26 to expand the requirements specified in Division 01 and Division 26 Sections "Basic Division 26 Electrical Requirements. This Section includes:

2. General Electrical Field Quality Control:
   a. Operational Testing.
   b. Functional Performance Testing.
   c. Corrective Action.
   d. System Certifications.
   e. Demonstrations and Training.

1.2 TESTING DESCRIPTION

A. Test, inspect, and calibrate electrical equipment and material installed and connected under Division 26. The purposes of these inspections, tests, and calibrations are to assure that the installed electrical systems and equipment, both Contractor and Owner supplied, are:

1. Installed in accordance with design specifications and manufacturer’s instructions.
2. Ready to be energized.
3. Operational and within industry and manufacturer’s tolerances.

B. Provide all material, equipment, labor and technical supervision to perform specified tests, inspections, studies and calibration.

C. Implement all testing at the project site.

1.3 ELECTRICAL ACCEPTANCE TESTING RESPONSIBILITIES

A. Contractor Responsibilities:

1. Pretesting:
   a. Perform routine insulation resistance, continuity and rotation tests for distribution and utilization equipment prior to and in addition to tests performed by the specified testing agency specified in this Section.
   b. Supply one set of the following for use in conjunction with electrical acceptance testing: short circuit analysis, coordination study, protective device setting table, complete set of electrical Drawings, Specifications and any pertinent Change Orders.

2. Scheduling:
   a. Schedule project to allow adequate time for electrical acceptance testing. Notify the testing agency through the Construction Manager when equipment becomes available for acceptance tests. Coordinate work to expedite inspection and test scheduling.
   b. Notify the Construction Manager, Owner, and Engineer not less than seven days prior to commencement of any testing.
3. Testing Agency Support:
   a. Supply a suitable and stable source of electrical power to each test site. Coordinate specific power requirements with the testing agency.
   b. Witness and report to the Construction Manager, Owner and Engineer, any system, material, equipment or workmanship which is found defective on the basis of acceptance tests or inspections by the testing agency.
   c. Maintain a written record of all tests and, upon completion of project, assemble and submit a certified final test report that includes the test procedures and test results for each system and equipment item.

4. Corrective Action:
   a. Within 15 days of direction from the Construction Manager, Owner or Engineer, rework, repair or replace any system, material, equipment or workmanship which is found defective on the basis of acceptance tests or inspections at the Contractor’s expense.

B. Testing Responsibilities:
   1. Independent Testing Agency: Engage an independent qualified testing and inspecting agency to perform field tests and inspections and prepare test reports for the equipment identified as "I" in the testing responsibility matrix below.
   2. Contractor Testing Agency: Engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports for the equipment identified as "C" in the testing responsibility matrix below.

C. Testing Responsibility Matrix:

<table>
<thead>
<tr>
<th>System</th>
<th>Testing Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic Lighting Control Equipment</td>
<td>C</td>
</tr>
<tr>
<td>Control Voltage Electrical Power Cables</td>
<td>C</td>
</tr>
<tr>
<td>Contactors</td>
<td>C</td>
</tr>
<tr>
<td>Dimming Systems</td>
<td>C</td>
</tr>
<tr>
<td>Disconnect Switches</td>
<td>C</td>
</tr>
<tr>
<td>Electric Metering Equipment</td>
<td>I</td>
</tr>
<tr>
<td>Equipotential Grounding Systems</td>
<td>C</td>
</tr>
<tr>
<td>Grounding Systems</td>
<td>C</td>
</tr>
<tr>
<td>Interior Lighting</td>
<td>C</td>
</tr>
<tr>
<td>Isolated Power Systems</td>
<td>I</td>
</tr>
<tr>
<td>Lighting Control Equipment</td>
<td>C</td>
</tr>
<tr>
<td>Lightning Protection Systems</td>
<td>I</td>
</tr>
<tr>
<td>Low Voltage Feeder Cable</td>
<td>C</td>
</tr>
<tr>
<td>Low Voltage Power Switchgear</td>
<td>I</td>
</tr>
<tr>
<td>Low Voltage Transformers</td>
<td>C</td>
</tr>
<tr>
<td>Medium Voltage Cable</td>
<td>I</td>
</tr>
<tr>
<td>Medium Voltage Transformers</td>
<td>I</td>
</tr>
<tr>
<td>Medium Voltage Surge Arresters</td>
<td>I</td>
</tr>
<tr>
<td>Motor Controllers</td>
<td>C</td>
</tr>
<tr>
<td>Panelboards</td>
<td>C</td>
</tr>
<tr>
<td>Protective Devices</td>
<td>I</td>
</tr>
</tbody>
</table>
1.4 GENERAL ELECTRICAL FIELD QUALITY CONTROL RESPONSIBILITIES

A. Contractor Responsibilities:
   1. Operational Tests.
   2. Functional Performance Testing.
   3. Corrective action other than calibration deficiencies.
   4. System Certifications.
   5. Demonstrations and Training.

1.5 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract, Division 01 Specification Sections, and Division 26 Section "Basic Division 26 Requirements."

1.6 INFORMATIONAL SUBMITTALS

A. Testing Agency Qualifications:
   1. Provide with exception to Owner Testing Agency.

B. Field Quality Control Test Reports:
   1. Field test reports.
   2. Field inspection reports.
   3. Demonstration reports.
   4. Manufacturer’s field reports.
   5. Systems Certifications.

1.7 CLOSEOUT SUBMITTALS

A. Submit a final report of testing and inspection at the completion of the project. Include the following information:
   1. Summary of the project.
   2. Description of the equipment tested.
   4. Description of the tests.
   5. Test results including electronic log of receptacle testing date in the format provided by the specified meter.
   6. Conclusions and recommendations.
   7. Appendix including appropriate test forms.
   8. Identification of the test equipment used and calibration date.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Demonstration and training materials and recorded electronic media.
1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: An agency with the experience and capability to conduct the testing indicated and that is acceptable to authorities having jurisdiction.

1. For electrical power equipment and systems, the agency shall be a member company of the International Electrical Testing Association (NETA) or is a Nationally Recognized Testing Laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
2. For other than electrical power equipment or where NETA is not a recognized testing agent, the testing agency shall be as defined in the appropriate Division 26 Section.
3. The testing agency shall have successfully completed not less than five acceptance testing, inspection, and calibration projects of similar scope to this project.
4. The testing agency lead, on site, technical person shall be currently certified Level III by the InterNational Electrical Testing Association (NETA) or National Institute for Certification in Engineering Technologies (NICET) in electrical power distribution system testing.
5. The testing agency shall only utilize engineers and technicians who are regularly employed by the firm for testing service.

B. Regulatory Requirements: Make inspections and testing in accordance with the local authorities having jurisdiction on in compliance with the following applicable codes and standards of the following agencies:

1. InterNational Electrical Testing Association:
2. National Fire Protection Association – NFPA:
   b. ANSI/NFPA 70B – Recommended Practice for Electrical Equipment Maintenance.
   c. NFPA 70E – Electrical Safety Requirements for Employee Workplaces.

C. Use the following references:

1. Project design specifications.
2. Project design drawings.
4. Manufacturer’s instruction manuals applicable to each particular apparatus.
5. Project list of equipment to be inspected and tested.

D. Safety and Precautions: Comply with required safety practices which include, but are not limited to, the following:

1. Occupational Safety and Health Act.
3. Applicable state and local safety operating procedures.

1.10 COORDINATION

A. Coordinate all electrical inspections and testing activities and reports through the Contractor to and from the Construction Manager.

B. Coordinate all testing assistance and preparations including manufacturer’s representatives at no additional cost to the Owner.
PART 2 - PRODUCTS

2.1 TEST EQUIPMENT GENERAL REQUIREMENTS

A. Use only test equipment that is in good mechanical and electrical condition.
B. Use true RMS measuring meters.
C. Field test metering used to check power system meter calibration shall have an accuracy higher than that of the instrument being checked.
D. Use test equipment with accuracy of metering that is appropriate for the test being performed.
E. Use test equipment with waveshape and frequency output that are appropriate for the test and tested equipment.

2.2 TEST EQUIPMENT QUALITY CONTROL

A. Use only equipment for testing and calibration procedures that has the following characteristics:
   1. Maintained in good visual and mechanical condition.
   2. Maintained in safe operating condition.
B. Use test equipment having operating accuracy equal to, or better than, the following limits:
   1. Portable Multimeters: True RMS measuring.
   2. Multimeters shall have the following accuracy limits, or better:
      a. AC Voltage Ranges: .75% +/- 3 last single digits @ 60 Hz.
      b. AC Current Ranges: .90% +/- last single digits @ 60 Hz, including adapters, transducers.
      c. DC Voltage Ranges: .25% +/- 1 last single digit.
      d. DC Current Ranges: .75% +/- 1 single digit.
      e. Resistance Ranges: .50% +/- 1 last single digit.
      f. Frequency Range: .10% +/- 1 single digit @ 60 Hz.
   3. Clamp-on Ammeters: AC current +/- 3% of range +/- 1 last single digit @ 60 Hz.
   4. Dissipation/Power Factor Field Equipment:
      a. +/- 0.1% power factor for power factor values up to 2.0%.
      b. 5% of the reading for power factor values above 2.0%.
   5. Low Range DC Resistance Equipment: 1.0% of reading, +/- 2 last single digits.
   6. Transformer Turns Ratio Test Equipment: 0.5% or better @ 60 Hz.
   7. Ground Electrode Test Equipment: +/- 2% of range.
   8. Insulation Test Sets: 0-1000V DC +/- 20% of reading at mid-scale.
   9. Electrical Load Survey Equipment:
      a. +/- 5% total error, including sensors.
      b. 1% resolution.
      c. Current Transformers: +/- 2% of range @ 50 Hz.
      d. Voltage Transformers: +/- 0.5% of range @ 60 Hz.
   10. Liquid Dielectric Strength Test Equipment: +/- 2% of scale.
   12. Phase Shifting Equipment: +/- 1.0 over entire range.
   13. High Current Test Equipment: +/- 2% or range.
   14. DC High Potential Test Equipment: +/- 2% of full scale.
   15. AC High Potential Test Equipment (60 Hz): +/- 2% of full scale.
2.3 TEST EQUIPMENT CALIBRATION

A. Test instruments shall be calibrated to references traceable to the National Bureau of Standards and shall have a current sticker showing date of calibration, deviation from standard, name of calibration laboratory and technician, and date recalibration is required.

B. Calibrate equipment in accordance with the following schedule:

1. Field Equipment: 6 months maximum.
2. Leased Specialty Equipment: 12 months (where accuracy is guaranteed by lessor).

C. Place dated calibration labels at visible locations on all test equipment.

D. Keep up to date records which show date and results of test equipment calibrated or tested; have such records available for review.

E. Maintain up to date test equipment calibration instructions and procedures for each test equipment.

F. Use calibration standards of higher accuracy than the accuracy of the test equipment being calibrated.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. General: Furnish the materials, equipment and personnel required for field testing of electrical Work as specified herein and in other specification sections. Perform tests in accordance with the Specification requirements.

B. Contractor shall be responsible to perform the following pre-acceptance testing procedures and tests:

1. Clean dirt, dust, and moisture from equipment.
2. Replace fuses blown during construction and testing.
3. Check for loose bus and cable connections.
4. Check for proper clearances of live parts, between phases and to ground and ascertain that required barriers are in place.
5. Check for missing insulation in equipment and on conductors.
6. Check for modifications, alterations, and the use of unapproved parts in the assembly of the equipment against the approved submittals.
7. Ascertain that fuse and circuit breaker short circuit interrupting ratings are adequate.
8. Ascertain that the equipment rooms and areas are free of dampness and moisture accumulations.
9. Check conductors run in multiple to ensure that they are properly phased.
10. Conduct a megger test of all equipment and wiring. Do not use battery operated test lights and bells for this test.
11. Contractor shall startup equipment following manufacturer recommendations and best safety practices.
12. Loads on all parts of electrical distribution systems shall be balanced, insofar as is practical. Particular attention shall be directed to the revision of labeling and marking of feeders, subfeeders and branch circuits as required for load balancing. All necessary revisions shall be incorporated into the "Final Record" drawing set.
13. Overload devices shall be installed and adjusted to suit the loads which they control.

ELECTRICAL INSPECTIONS AND TESTING
C. Field Tests and Inspections:
1. Schedule field tests and inspections with at least seven (7) days advance notice to Construction Manager, Owner and Engineer.
2. Use testing equipment appropriate for the tests in conjunction with industry product testing and performance guidelines and calibrated to assure test quality.
3. Comply with latest edition of ANSI/NETA ATS – Standard for Acceptance Testing and addition requirements defined in the appropriate Division 26 Sections for field testing of electrical power equipment, systems and components.
4. Comply with field testing requirements defined in the appropriate Division 26 Sections for other than electrical power equipment.
5. Follow up testing shall be included under testing responsibility matrix.
6. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, responsible agency and representative, and date.

D. Field Test Reports:
1. Submit field test reports and inspection logs in compliance with Division 01 Section "Quality Requirements" for each of the systems defined in the testing responsibility matrix and other special tests defined in the appropriate Division 26 Sections.
2. Refer to Commissioning Plan for additional requirements.

E. Operational Tests: After the work is complete and properly adjusted, the Contractor shall conduct operational tests as directed by Construction Manager, Owner or Engineer. Perform tests in the presence of Construction Manager, Owner and Engineer. Operational tests as herein specified are defined as those tests and inspections which are required to ensure that the equipment involved is operating and functioning as specified or intended and within industry practices, standards and manufacturers tolerances and meet the performance as stated in the specification.
1. Demonstration: Demonstrate that all equipment and systems operate in accordance with the requirements of the Contract Documents. Where specified that the equipment manufacturer shall provide such demonstrations and costs for these services shall be at the Contractor's expense.
2. Voltage Test: Refer to specification 262726 Wiring Devices for testing requirements.
3. Cable Insulation: After cables are pulled in place and before connecting, test to determine that conductor insulation resistance is not less by megger test than that recommended by ICEA. Cables failing insulation test shall be removed, replaced and re-tested.
4. Transformers and Equipment: Test each entire system after final connections are made and verify each component shall pass drop in potential resistance tests.
5. Motors: Test motors under load with ammeter readings taken in each phase, and the RPM of motors recorded at the time. Test motors for correct direction of rotation.
6. Ground Testing: Subject the completed equipment grounding system to a meggered test at the substation ground bus to ensure that the ground resistance, without chemical treatment or other artificial means, does not exceed 5 ohms. If the system does exceed 5 ohms, alert the design team to discuss further remedies or if the recorded reading will be acceptable.
7. Control circuits shall be checked for proper functioning and fail-safe operation. The "Auto" position of all "Hand-Off-Auto" controlled equipment shall be checked for proper operation and interlocking with other equipment.
8. Lighting switching shall be tested for correct operation, with particular attention to 3 and 4 way switching and dimming system installations.
9. Receptacles shall be checked for correct and consistent phase and neutral positions. Ground receptacles shall also be tested for location and effectiveness of the grounded contact. Ground fault interrupter receptacles shall be tested for proper operation by simulating an actual line to ground fault at the receptacle. Refer to specification 262726 for additional receptacle testing requirements including but not limited to the requirements of NFPA 99.

F. Functional Performance Testing:
1. Perform functional performance testing together with representatives of other trades associated with the installation per the requirements of Division 20 Section "Functional Performance Testing – Common Work Results – Division 21 through 28.
2. Perform function tests on each system included in this Section to ensure total system operation.
3. Perform the system functional test upon satisfactory completion of equipment acceptance tests. It is the intent of system functional tests to prove the proper interaction of all sensing, processing and action devices to effect the designed end product or result.
4. Test interlocks, safety devices, fail-safe functions, and design functions.

G. Corrective Action:
1. Correct calibration deficiencies identified in field tests. Other deficiencies shall be corrected by Division 26.
2. Retest and reinspect per the requirements of Division 01 Section "Quality Requirements".

H. System Certifications:
1. Notify the Engineer in writing upon completion of the work, that the entire electrical installation has been examined, inspected, tested, and calibrated or adjusted as specified and that it is ready for final inspection.
   a. Provide written certifications, prior to the final inspection, for each system or piece of equipment indicating that the equipment has been tested and meets the performance criteria of the Contract Documents.
   b. Provide system certifications per the requirements of Division 20 Section "Systems Certifications – Common Work Results – Division 21 through 28."

Obtain Certificates of Compliance on completion of the work with written approval or acceptance from all authorities having jurisdiction over the work and deliver these to the Engineer. The work shall not be deemed to have reached a state of final completion until these certificates have been delivered.

I. Demonstration and Training:
1. Provide Owner's personnel demonstration and training for Division 26 equipment and systems to expand the requirements specified in Division 01 Section, "Demonstration and Training" as follows:
   a. Owner's personnel demonstration and training shall be considered an inspection and testing function and shall be reported as such including correction of all deficiencies. Include general and emergency modes of operation.
   b. All demonstrations and training shall be recorded on digital electronic media for future reference.
   c. Training shall start with classroom sessions, if necessary, followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including start up, shutdown, fire alarm, power failure, etc.
d. During any demonstration, should the system fail to perform in accordance with the requirements of the Operations and Maintenance (O&M) manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

e. The appropriate trade or manufacturer’s representative shall provide the instructions on each major piece of equipment. This representative may be the start up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

f. The training sessions shall follow the outline in the table of contents of the O&M manual and illustrate whenever possible the use of the O&M manuals for reference.

g. Training shall include:

1) Usage of the printed installation, operation and maintenance instruction material included in the O&M manuals.
2) Review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start up, operation in all modes possible, shutdown, seasonal changeover and any emergency procedures.
3) Discussion of relevant health and safety issues and concerns.
4) Discussion of warranties and guarantees.
5) Common troubleshooting problems and solutions.
6) Explanation of information included in the O&M manuals and the location of all plans and manuals in the facility.
7) Discussion of any peculiarities of equipment installation or operation.

h. Hands on training shall include start up, operation in all modes possible, including manual, shutdown, and any emergency procedures and maintenance of all pieces of equipment.

3.2 PROJECT REPORTS

A. Consistent project reports shall be similar to the following:
ELECTRICAL INSPECTION AND TESTING REPORT

Project: _________________  Contact No. _________

Equipment Ref. No. _________________  Serial No.: _________

Inspection Date: _________________  Inspecting Organization: _________

Performed By: _________  Report No.: _________

Contractor, Architect/Engineer Representative Present:

________________________________________________________________________

Ref. Specification: ________________________________________________________

A. Inspections Performed: __________________________________________________

________________________________________________________________________

(Attach manufacturer’s recommended demonstration.)

B. Summary of Inspection: ________________________________________________

________________________________________________________________________

C. Attached Manufacturer’s Demonstration
   Report No. of Attached Sheets _________

D. Signatures:
   Contractor, Architect/Engineer Representative: ________________________________
   Testing Contractor: ________________________________________________________
**ELECTRICAL OPERATIONAL TEST REPORT**

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Contractor, Architect/Engineer Representative Present:

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**A. Test Performed:**

(Attach manufacturer’s recommended demonstration.)

**B. Summary of Results:**

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**C. Attached Test and Results**

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Contractor,
Architect/Engineer Representative:

Testing Contractor:
ELECTRICAL ACCEPTANCE TEST REPORT

Project: ______________  Contact No.: _____

Equipment Ref. No. ______________  Serial No.: _____

Test Date: ______________  Test Organization: _____

Performed By: ______________  Report No.: _____

Contractor, Architect/Engineer Representative Present:

________________________________________________________________________

________________________________________________________________________

Test Equipment: _______________________________________________________________________________________

________________________________________________________________________

Ref. Specification: _______________________________________________________________________________________

A. Methodology Test: _______________________________________________________________________________________

(Attach manufacturer’s recommended demonstration.)

B. Summary of Results: _______________________________________________________________________________________

________________________________________________________________________

C. Attached Test and Results Report No. of Attached Sheets _______________________________________________________________________________________

D. Signatures:

Contractor, Architect/Engineer Representative: _______________________________________________________________________________________

Testing Contractor: _______________________________________________________________________________________
ELECTRICAL DEMONSTRATION AND TRAINING REPORT

Project: ___________ Contact No. ______

Equipment
Ref. No. ___________ Serial No.: ______

Demonstration Date: ___________ Demonstrating Organization: ______

Performed By: ________ Report No.: ______

Contractor, Architect/Engineer, Owner Representative Present:

________________________________________________________________________

Ref. Specification: __________________________________________________________

A. Demonstration Performed: _________________________________________________

(Attach manufacturer’s recommended demonstration.)

B. Summary of Demonstration: ________________________________________________

________________________________________________________________________

C. Attached Manufacturer’s Demonstration Report No. of Attached Sheets ________

D. Signatures:

Contractor, Architect/Engineer, Owner Representative: __________________________

Testing Contractor: __________________________________________
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**DIVISION 26 INSPECTIONS AND TESTING SUMMARY REPORT**

Project: Report No.: Contact No.: Date:

**ELECTRICAL INSPECTIONS AND TESTING**

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SECTION 260513 - MEDIUM VOLTAGE CABLE (601 - 35,000 VOLTS)

PART 1 - GENERAL

1.1 SUMMARY
   A. This section includes single and multiple conductor cables and splices, connectors, terminations, and accessories for 601 to 35,000 volt electrical distribution systems.

1.2 ADMINISTRATIVE REQUIREMENTS
   A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
      1. Notify Construction Manager and Owner no fewer than fourteen (14) days in advance of proposed interruption of electric service.
      2. Do not proceed with interruption of electric service without Construction Manager's or Owner's written permission.

1.3 SUBMITTALS
   A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of cable indicated. Include splices, terminations and cable pulling calculations for cables and cable accessories.
   B. Shop Drawings: Factory quality control test reports on identical cables.
   C. Samples: 16 inch (400 mm) lengths of each type of cable specified.

1.5 INFORMATIONAL SUBMITTALS
   A. Qualification Data:
      1. Source Quality Control Test Reports.
      2. Supplier Qualifications.
      3. Installer Qualifications.
      4. Testing Agent Qualifications.
   B. Material Certificates: For each cable and accessory type, signed by manufacturers.
   C. Layout Drawings: Identify each separable insulated connector and splice location including associated cable routings.
   D. Field quality control test reports.

1.6 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data:
1. Maintenance data for cables and accessories for inclusion in Operation and Maintenance manual specified in Division 01 and in Division 26 Section "Basic Division 26 Requirements." In addition to the requirements specified there, include:
   a. Manufacturer's written instructions for periodic tests of cables in service.
   b. Cable accessories.
   c. Termination and splicing instructions.
   d. Cable testing procedures.

B. Record Documents:
   1. Accurately record actual sizes, locations of cables and pulling tensions.

1.7 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium voltage cable. The installer shall be experienced in medium voltage cable installation. Workmen involved in splicing and termination of cables shall have been specifically trained and certified by the cable manufacturer or NETA in the procedures required for the splices and terminations used in this project. At the Engineer’s discretion, the installer shall make up, at the Contractor’s expense, a sample splice and/or termination to be used to determine the capability of the electrician(s) involved.

B. Source Limitations: Obtain accessories through one source from a single manufacturer.

C. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
   2. General Electrical Field Quality Control.

D. Comply with IEEE C2, NFPA 70, and NFPA 70E.

E. Comply with IEEE 48, Standard for Test Procedures and Requirements for Alternating Current Cable Terminations used on shielded cables having laminated insulation rated 2.5 kV through 765 kV.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver medium voltage cable on factory reels conforming to NEMA Standard WC 26, "Wire and Cable Packaging."

B. Store cables on reels on elevated platforms in a clean, dry location.

1.9 WARRANTY

A. Special Project Warranty: Submit a written warranty, mutually executed by manufacturer and the principal Installer, agreeing to repair or replace medium voltage cables, splices, and terminations that fail in materials or workmanship within the special project warranty period specified below. This warranty shall be in addition to, and not a limitation of, other rights and remedies the Owner may have against the Contractor under the Contract Documents.

   1. Special Project Warranty Period: 20 years beginning on the date of Substantial Completion.
PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Cable:
      a. The Okonite Company.
      b. Prysmian Group.
      c. Southwire Company.
   2. Cable Splicing and Terminating Products and Accessories:
      a. ABB.
      b. Eaton; Cooper Power Series.
      c. 3M; Electrical Products Division.
      d. M.P. Husky Corp.
      e. Raychem Corporation; a Division of TE Connectivity.

2.2 REGULATORY REQUIREMENTS
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
B. Comply with IEEE 386, Standard for Separable Insulated Connector System for Power Distribution Systems above 600 V.
C. Comply with IEEE 404, Standard for Cable Joints for Use with Extruded Dielectric Cable.
D. Comply with ANSI/NETA ATS, Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems for field testing.
E. Comply with UL 1072, Medium Voltage Power Cables.
F. Comply with NEMA WC8, ERR Insulated Wire and Cable.
G. Comply with all AIEC and ICEA standards for medium voltage cables.

2.3 CABLES
A. Cable Type: MV105.
B. Comply with UL 1072 and AEIC CS 8.
C. Conductor: Copper.
D. Conductor Stranding: Compact or compressed round, concentric lay, Class B.
E. Conductor Insulation: EPR and EPDM types.
   1. Voltage Rating: 15 kV.
   2. Insulation Level: 133 percent insulation level.
F. Metallic Shielding: 5 mil copper tape with 20 percent overlap or solid copper wires, helically applied over semiconducting insulation shield.
G. Single Conductor Cable Assembly: Three independent insulated, shielded conductors with ground conductors. Multiple conductor cable assemblies are prohibited.

H. Cable Jacket: Sunlight resistant PVC.

2.4 SPLICE KITS
A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.
B. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.
   1. Combination tape and cold shrink rubber sleeve kit with rejacketing by cast epoxy resin encasement or other waterproof, abrasion resistant material.
   2. Heat shrink splicing kit of uniform, cross section, polymeric construction with outer heat shrink jacket.
   3. Premolded, cold shrink rubber, in line splicing kit.
   4. Premolded EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.

2.5 SOLID TERMINATIONS
A. Shielded Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.
   1. Class 1 Terminations: Modular type, furnished as a kit, with stress relief tube; multiple, molded silicone rubber, insulator modules; shield ground strap; and compression type connector.
   2. Class 1 Terminations: Heat shrink type with heat shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression type connector.
   3. Class 1 Terminations: Modular type, furnished as a kit, with stress relief shield terminator; multiple wet process, porcelain, insulator modules; shield ground strap; and compression type connector.
   4. Class 1 Terminations, Indoors: Kit with stress relief tube, nontracking insulator tube, shield ground strap, compression type connector, and end seal.
   5. Class 2 Terminations, Indoors: Kit with stress relief tube, nontracking insulator tube, shield ground strap, and compression type connector. Include silicone rubber tape, cold shrink rubber sleeve, or heat shrink plastic sleeve moisture seal for end of insulation whether or not supplied with kits.

2.6 SEPARABLE INSULATED CONNECTOR SYSTEMS
A. Description: Modular system, complying with IEEE 386, with disconnecting, single pole, cable terminators and with matching, stationary, plug in, dead front terminals designed for cable voltage and for sealing against moisture.
B. Dead Front Equipment Connections:
1. Dead Break Cable Terminators: Elbow type unit with 600 A continuous current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

C. Tool Set: Shotgun hot stick with energized terminal indicator, fault indicator test tool, and carrying case.

2.7 ARC PROOFING MATERIALS

A. Tape for First Course on Metal Objects: 10 mil (250 micrometer) thick, corrosion protective, moisture resistant, PVC pipe wrapping tape.

B. Arc Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, compatible with cable jacket.

C. Glass Cloth Tape: Pressure sensitive adhesive type, 1/2 inch (13 mm) wide.

2.8 SOURCE QUALITY CONTROL

A. Test and inspect cables according to AIEC and ICEA Standards before shipping.

B. Test strand filled cables for water penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine raceways, cable trays, pull boxes, manholes, junction boxes, and other cable installation locations for cleanliness of raceways, minimum bending radii of cables, and conditions affecting performance of cable. Pull a mandrell through raceways to check for suitable conditions. Do not proceed with cable installation until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Install cable accessory items in accordance with manufacturer's written instructions and as indicated.

3.3 INSTALLATION OF CABLES

A. Install cables according to IEEE 576.

B. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

1. Where necessary, use manufacturer approved pulling compound or lubricant that will not deteriorate conductor or insulation.

2. Use pulling means, including fish tape, cable, rope, and basket weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.

C. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
D. Support cables according to Division 26 Section "Hangers and Supports."

E. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.

F. Install cable splices at pull points and elsewhere as indicated; use standard kits. Provide splice supports independent of cable. Use of separate cable support brackets is acceptable.

G. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits.

H. Arc Proofing: Unless otherwise indicated, arc proof medium voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc proofing tape manufacturer's written instructions, apply arc proofing as follows:
   1. Clean cable sheath.
   2. Wrap metallic cable components with 10 mil (250 micrometer) pipe wrapping tape.
   3. Smooth surface contours with electrical insulation putty.
   4. Apply arc proofing tape in one half lapped layer with coated side toward cable.
   5. Band arc proofing tape with 1 inch (25 mm) wide bands of half lapped, adhesive, glass cloth tape 2 inches (50 mm) o.c.

I. Seal around cables passing through fire rated elements according to Division 07 Section "Penetration Firestopping."

J. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated connector fittings, and hardware.

K. Identify cables according to Division 26 Section "Electrical Identification."

3.4 FIELD QUALITY CONTROL

A. Inspection and Tests:
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS "Cables, Medium and High Voltage", "System Functional Tests", and "Thermographic Survey" requirements, and the following additional requirements.
      a. Follow up thermographic survey shall not be required.
      b. Prepare test and inspection reports.

B. Contractor shall furnish a set of Contract Documents and manufacturer's recommendations to test organization and make power available at test locations.

C. Tests shall include high potential test of cable and accessories and such tests and examinations required to achieve specified objectives (See Appendix "A"). Where new cables are spliced to existing cables, the high potential test shall be performed on the new cable prior to splicing. After test results for new cables are approved and splice is made, an insulation resistance test and continuity test on the length of cable including the splice with the existing cables being tested to the nearest disconnect point.

D. Test Objectives: To assure cable installation is operational within industry and manufacturer's tolerances, is installed in accordance with Contract Documents, and is suitable for energizing.

E. Procedures: Comply with the INETA standard, IEEE Standard 48, and IEEE 400. Upon satisfactory completion of tests, attach a label to tested components.
3.5  INFRARED SCANNING

A. Infrared Scanning: After Substantial Completion, perform an infrared scan of medium voltage cable connections. Six months post occupancy provide an additional infrared scan of the medium voltage cable connections.

3.6  CLOSEOUT ACTIVITIES

A. Demonstration: Provide demonstration of Owner’s maintenance personnel in the location of separable insulated connectors.
# Appendix A

## Reporting Form - DC Proof Testing

### Testing Company Name

[Insert Testing Company Name]

### Customer

[Insert Customer Name]

### Location

[Insert Location]

### Date of Test

[Insert Date]

### Tester's Name

[Insert Tester's Name]

### Humidity

[Insert Humidity %]

### Temperature

[Insert Temperature]

### Weather

- [ ] Cloudy
- [ ] Rain
- [ ] Snow
- [ ] Fog
- [ ] Sunny

### Phase Identification

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### KV Test Voltage

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### Microamperes

- [ ] A
- [ ] A
- [ ] A

### Operating Voltage

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### Test Set Leakage

- [ ] 15 seconds
- [ ] 30 seconds
- [ ] 45 seconds
- [ ] 1 minute
- [ ] 2 minutes
- [ ] 3 minutes
- [ ] 4 minutes
- [ ] 5 minutes
- [ ] 6 minutes

### Type of Insulation

[Insert Type of Insulation]

### Number of Conductors

[Insert Number of Conductors]

### Length

[Insert Length]

### Age

[Insert Age]

### Type of Jacket

[Insert Type of Jacket]

### Separate Neutral

[Insert Separate Neutral]

### Or Copper Neutral Tape

[Insert Or Copper Neutral Tape]

### Or Concentric Neutral Wires

[Insert Or Concentric Neutral Wires]

### Type of Terminations at Test End

[Insert Type of Terminations at Test End]

---

**Medium Voltage Cable (601 - 35,000 Volts)**

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END OF SECTION 260513
SECTION 260519 - LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
(100-600 VOLTS)

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes conductors, cables, and connectors rated 100 to 600 volts.

1.2 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.3 ACTION SUBMITTALS
A. Product Data:
   1. Multiconductor cables.
   2. Box fittings approved for use with healthcare facilities MC cables.
B. Shop Drawings:
   1. Calculations for conductor and associated conduit deratings for:
      a. Panelboard branch circuit conductors when over seven current carrying conductors are combined in common conduit. Field installations found without such calculations will be rejected.
      b. Conductor alterations from Drawings.

1.4 INFORMATIONAL SUBMITTALS
A. Qualification Data: For testing agency.
B. Field quality control test reports.

1.5 CLOSEOUT SUBMITTALS
A. Record Documents:
   1. Indicate all feeder sizes on the record drawings riser diagrams.
   2. Indicated homerun junction box locations for all branch circuits.

1.6 QUALITY ASSURANCE
A. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
   2. General Electrical Field Quality Control.
C. Maximum Cable Pull Compliance: Comply with manufacturer’s maximum cable tension pulling characteristics so as not to damage wire and cable.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Conductors and Cables:
   a. AFC Cable Systems, Inc., a Division of Atkore
   b. Alcan Products Corporation; Alcan Cable Division
   c. American Insulated Wire Corp.; a Soutwire Company
   d. Cerrowire LLC
   e. Encore Wire Corporation
   f. The Okonite Company
   g. Prysmian Group
   h. Republic Wire Inc
   i. Southwire Company

2. Connectors and Splices for Conductors and Cable Conductors:
   a. ABB
   b. AFC Cable Systems, Inc., a Division of Atkore
   c. AMP, a Division of TE Connectivity
   d. Burndy Corporation, a Division of Hubbell Power Systems, Inc
   e. ILSCO
   f. O-Z/Gedney; Emerson Electric Co
   g. 3M; Electrical Products Division
   h. NSI Industries
   i. Raychem Corporation; a Division of TE Connectivity
   j. Square D by Schneider Electric USA
   k. Wago USA(Clear body style)

2.2 REGULATORY REQUIREMENTS

A. Comply with provisions of the following codes and standards:

1. NFPA 20 Centrifugal Fire Pumps
2. NFPA 70 National Electrical Code
   a. Conform to applicable codes and regulations regarding toxicity of combustion products of insulating materials

3. UL Compliance: Provide components which are listed and labeled by UL under the following standards:
   a. UL Std. 44 – Thermoset-Insulated Wires and Cables
   b. UL Std. 83 - Thermoplastic-Insulated Wires and Cables
2.3 WIRES AND CABLES

A. General: Provide wire and cable suitable for the temperature, conditions and location where indicated.

1. Derate conductors per the NEC for installations that are exposed to direct sunlight, are on and/or above rooftops where ambient temperatures are other than 30 deg. C (86 deg. F).

B. Conductor Material: Copper and Aluminum.

C. Conductors: Provide solid conductors for power and lighting circuits sizes No. 16 AWG and smaller. Provide stranded conductors for sizes No. 14 AWG and larger.

D. Insulation: Provide insulation type in accordance with Part 3 below.

c. UL Std. 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors.

d. UL Std. 1569 - Metal-Clad Cable.

4. NEMA/ICEA Compliance: Provide components which comply with the following standards:


5. IEEE Compliance: Provide components which comply with the following standard:

a. Std. 82 - Test procedures for Impulse Voltage Tests on Insulated Conductors.
E. **Color Coding:** Color shall be the full thickness of the insulation, not applied electrical tape.

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F. **Jackets:** Factory-applied nylon or PVC external jacketed wires and cables for pulls in raceways over 100-feet in length, for pulls in raceways with more than three equivalent 90 deg. bends, for pulls in conduits underground or under slabs on grade, and where indicated.

G. **Multiconductor Cables:** Provide the following type(s) of cables in NEC approved locations and applications where indicated. Provide cable UL listed for particular application:

1. **Metal-Clad Cable:** Type MC:
   a. Complete with ground conductor.
   b. Approved for use in Health Care Facilities patient areas – Metal-clad cable for use in Health Care Facilities shall be UL listed and labeled by Underwriters Laboratories as Metal-Clad – All Purpose (MC-AP). The cable shall contain an insulated green copper grounding conductor which is factory installed, along with color coded circuit conductors and a separate bonding wire. The assembly shall be protected by interlocked aluminum armor painted green and shall provide redundant, dual path grounding. Cable shall meet the requirements of National Electrical Code Article 517.
      1) Basis of Design: Type HCF MC – AP

2. **Portable Cord:** Type SO.

H. Conductor for isolated power systems shall have a distinctive color stripe other than white, green, or gray along the entire length of the conductor as required in NEC.

I. Dedicated neutral conductors shall have a distinctive color stripe to match the color of the phase conductor with which it is associated.
2.4 CONNECTORS FOR CONDUCTORS
   A. Provide UL listed factory-fabricated, solderless metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Use connectors with temperature ratings equal to or greater than those of the wires upon which used.
      1. Split-bolt connectors shall not be used for any application.

2.5 CONDUCTOR PULLING GRIPS
   A. At Contractor’s option, factory installed pulling grips may be provided to allow potential reduced pulling tension and a low profile head.

2.6 CONDUCTOR PULLING JACKET
   A. At Contractor’s option, lubricated type conductor pulling jackets may be provided for THHN and XHHW conductors to allow potential reduced pulling tension. Lubricated type conductors shall not be permitted for wiring associated with Isolated Power Systems.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. General: Install electrical cables, conductors and wiring connectors as indicated, in compliance with applicable requirements of NEC, NEMA, UL, and NECA's "Standard of Installation," and in accordance with recognized industry practices.
      1. Install all conductors within raceways or approved cables.
      2. Install conductors and cables run under the building slab in raceways.
      3. Install minimum No. 12 AWG for circuits 100 volts and above.
      4. Increase conductor size as required due to NEC derating requirements and availability. Minimum conductor sizes, based upon NEC Ampacity Table 310.15 (B) (16), (310.16 for NEC prior to 2014) and maximum 40 percent conduit raceway fill, are shown on Drawings. Generally use 60 deg. C ratings below 100 amperes and 75 deg. C rating above 100 amperes. If conductor size increased, be responsible for associated conduit size, based upon NEC Ampacity Tables and maximum 40 percent conduit raceway fill, and increased ground conductor size per NEC. If raceway type altered, also be responsible for associated conduit raceway size per NEC to meet 40 percent maximum fill.
      5. Keep conductor splices to a minimum.
      6. Do not bend conductors and cables, either permanently or temporarily during installation to radii less than that recommended by the manufacturer.
      7. Provide slack wire for all future connections with ends of wires taped and blank box covers installed.
      8. Provide conductors of the same size from the protective device to the last load.
      9. Make conductor length identical for parallel feeders.
     10. Ground and continuously polarize systems properly throughout following the color coding specified.
     11. Support conductors in vertical raceways. One cable support shall be provided at the top or as close to the top as practical, plus a support for each additional interval of spacing per NEC.

LOW VOLTAGE ELECTRICAL POWER CONDUCTORS
AND CABLES (100-600 VOLTS)
12. Install exposed cable parallel and perpendicular to surfaces, or exposed structural members, and following surface contours, where possible.

13. Support cables according to Division 26 Sections "Hangers and Supports."

14. In general homerun conduits shall be 1-inch minimum and contain a maximum of eight (8) #10AWG current carrying conductors unless permitted otherwise by Engineer or Owner.

15. Isolated Power System conductors shall be installed as short as possible. Coordinate conduit installation to ensure distances are limited.

B. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.

2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.

3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtailed.

4. When conductors larger than No. 12 AWG are installed on 15 – 20-A circuits, splice No. 12 AWG pigtails for device connections.

5. Existing Conductors:
   a. Cut back and pigtail, or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

C. Dedicated Branch Circuit Neutrals:

1. Provide dedicated neutrals for all branch circuits.

D. Coordinate conductor and cable installation work including electrical raceway and equipment installation work, as necessary to properly interface installation of wires and cables with other work.

1. Pull conductors simultaneously where more than one is being installed in same raceway.

2. Use of pull compound or lubricant is to be avoided unless absolutely necessary and other reduced cable tension pulling methods exhausted; compound used must not deteriorate conductor or insulation, and be one of the following:
   a. Ideal-Aqua-Gel.
   b. Polywater.
   c. Yellow 77.

3. Use of pull compound or lubricant shall not be permitted for wiring associated with Isolated Power Systems.

4. Use pulling means including lubricated conductor jackets, fish tape, cable, rope and basket weave wire and cable grips which will not damage cables or raceway.

E. Use conductors with 90 degree C insulation and appropriate NEC derating factors when wiring is within seven feet of passing over or attached to the following:

1. Boilers and other heat producing equipment.
2. Hot water heaters.
3. Rooftop and exposed exterior locations.
3.2 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper for phase conductors of feeders smaller than 125A; copper or aluminum for phase conductors of feeders 125A and larger.

B. Branch Circuits: Copper.

3.3 CONDUCTOR APPLICATIONS

A. Install UL Type THHN or THWN wiring in conduit, for branch circuits #10 and smaller.
   1. Include wet location label when installed in underground or above grade exterior raceways.

B. Install UL Type XHHW or THHN wiring in conduit, for feeders and branch circuits #8 and larger.
   1. Include wet location label when installed in underground or above grade exterior raceways.

C. Install UL Type XHHW or THWN wiring in conduit, for feeders and branch circuits installed outside of the building envelope, in raceway in contact with soil, or whenever raceway may be subject to moisture and/or condensation.

D. Install UL Type XHHW wiring in conduit for isolated power branch circuits.

E. Install SO hard service cord with stainless steel, wire mesh, strain relief at terminations to suit application.

3.4 EQUIPMENT CONNECTIONS

A. Follow circuit numbers shown on Drawings in connecting circuits to panelboards. In the event that field observation shows that the indicated circuit numbers are not connected to the corresponding panel overcurrent device, make all corrections necessary. Each branch circuit homerun containing two or more circuits with a common neutral shall be connected to the circuit breaker or switch in a three- or four-wire branch circuit panelboard so that no two of the circuits will be fed from the same phase.

B. Provide all wiring to and between motors, controllers, line voltage (120-600 volt) control devices, disconnect switches, and other related electrical equipment, except where such items are factory wired.

C. Terminate power wiring for elevator systems at the respective controller, and be in compliance with the manufacturer's approved shop drawings.

D. Provide power and all wiring connections to the control devices for electrically operated overhead doors, door operators and control devices which will be provided under another division.

E. Connectors for Splices, Taps, and Terminations:
   1. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connector and terminals to comply with tightening torques specified in UL Std. 486A and B.
   2. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings that unspliced conductors.

LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (100-600 VOLTS)
3.5 METAL-CLAD CABLE (TYPE MC CABLE)

A. May be used only when approved by the local authority having jurisdiction and only for concealed branch circuit wiring in spaces above ceilings and in hollow studded interior partitions starting twenty-five feet maximum from first wiring device off a rigid metallic homerun raceway. MC Cable shall not be used for homeruns.

B. In general, may be used only for lighting and convenience outlet wiring, and only for those branches and areas which are not identified herein as exceptions.

C. The exception branches and areas where MC Cable is not acceptable for lighting and convenience outlet wiring are as follows:

1. Critical branch circuits.
2. Diagnostic/therapeutic equipment (x-ray, etc.).
3. Emergency branch circuit.
4. Exposed locations.
5. Exterior circuits.
6. Hazardous locations.
7. Isolated grounding device branch circuits.
8. Life safety branch circuits.
9. Mechanical, electrical, battery and boiler rooms.
10. Sitework.
11. Through fire and smoke barriers.
12. Wet and damp locations.
D. MC cable shall be secured at intervals not exceeding 6 feet and within 12 inches of every outlet box or fitting. Luminaire whips may be 6 feet maximum without support.

E. At all terminations, a fitting shall be provided to protect the conductors from abrasion. Approved insulating bushings shall be provided between the conductors and the armor. The connector or clamp by which the cable is fastened to boxes or cabinets shall be metal, UL approved for use with MC cable, and of such design that the insulating bushing will be visible for inspection. Internal box cable clamps are not acceptable.

F. Metal-clad cable for use in Health Care Facilities shall be UL listed and labeled by Underwriters Laboratories as Metal-Clad – All Purpose (MC-AP). The cable shall contain an insulated green copper grounding conductor which is factory installed, along with color coded circuit conductors and a separate bonding wire. The assembly shall be protected by interlocked aluminum armor painted green and shall provide redundant, dual path grounding. Cable shall meet the requirements of National Electrical Code Article 517. This cable shall not be used for branch circuit wiring in the following applications:

3. Emergency systems (NEC 700).
4. Legally required standby systems (NEC 701).
5. Optional standby systems (NEC 702).

3.6 MAXIMUM BRANCH CIRCUIT LENGTHS

A. Per NEC and as shown on Drawings.

3.7 CONDUCTOR AND CABLE IDENTIFICATION

A. Conductors shall have solid color coded insulation per Division 26 Section "Electrical Identification."

3.8 WIRING METHODS

A. The following wiring methods shall not be used:

1. Non-metallic sheathed cable.

3.9 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.10 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping".
3.11 FIELD QUALITY CONTROL

A. Inspection and Tests:

1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS "Cables, Low-Voltage, 600-Volts Maximum", "System Functional Tests", and "Thermographic Survey" requirements, and the following additional requirements:

   a. Limit tests to:
      1) Service entrance conductors.
      2) Feeder and 3 phase motor conductors.

   b. Follow-up thermographic survey shall not be required.

   c. Prepare test and inspection reports.

END OF SECTION 260519
SECTION 260526 – GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes solid grounding of building structures and electrical systems and equipment. It includes basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other sections of these Specifications. Types of grounding systems include the following:
   1. Electrical System and Transformer Grounding.
   2. Building Grounding.
   3. Equipment Room Ground Terminal Bar.
   5. Surge Protective Device (SPD) Grounding.

1.2 DEFINITIONS
A. Ground (Earth): An intentional or accidental connection to Earth.
B. Bonding (Bonded): The joining of metallic parts together to form an electrically conductive path.
C. Equipotential Ground: Grounded bonded metallic parts to minimize electrical circulating currents between them for human safety.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.4 INFORMATIONAL SUBMITTALS
A. Qualification Data: For testing agency and testing agency's field supervisor.
B. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For grounding to include in emergency, operation and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data", include the following:
   1. Instructions for periodic testing and inspection of grounding features at test wells grounding connections for separately derived systems based on NETA MTS and NFPA 70B.
      a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
      b. Include recommended testing intervals.
B. Record Documents: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:

1. Ground rods.
2. Grounding arrangements and connections for separately derived systems.

1.6 QUALITY ASSURANCE

A. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:

2. General Electrical Field Quality Control.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following listed manufacturers:

1. Ground Rods:
   a. Burndy.
   b. Erico Products.
   c. Knight Metalcraft.
   d. Nehring.
   e. Harger Lightning and Grounding.

2. Molded Fusion Welding Material:
   a. Burndy.
   b. Cadweld.
   c. ThermOweld.
   d. Harger Lightning and Grounding UltraWeld®.

3. Irreversible Compression Connectors:
   a. Burndy Hyground Series.
   b. Structured Ground™.
   c. Thomas & Betts Corp.
   d. E-Z-Ground® Series.
   e. Harger Lightning and Grounding

4. Ground Clamps/Connectors:
   a. Adalet – PLM Division; a Division of Scott Felzer.
   b. Anderson Corp.
   c. Anixter Bros., Inc.
   d. Burndy.
   f. Crouse-Hinds, a Division of Cooper Industries.
   g. Erico Products.
5. Enclosure Equipment Grounding Kits:
   a. Same manufacturer as box/cabinet or for ground clamps/ connectors.

2.2 REGULATORY REQUIREMENTS
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   B. Comply with UL 467 for grounding and bonding materials and equipment.
   C. Comply with ANSI/TIA/EIA-607A – Commercial Building Grounding, Earthing and Bonding Requirements for Telecommunications.
   E. Comply with ANSI/TIA/EIA-607B – Commercial Building Grounding, Earthing and Bonding Requirements for Telecommunications.

2.3 GROUNDING AND BONDING PRODUCTS
   A. Products: Of types indicated and of sizes and ratings to comply with NEC requirements. Where types, sizes, ratings, and quantities indicated are in excess of NEC requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.

2.4 CONDUCTORS
   A. General:
      1. Comply with Division 26 Section "Low Voltage Electrical Power Conductors and Cables."
      2. Conductors: Install solid conductor for No. 16 AWG and smaller, and stranded conductors for No. 14 AWG and larger, unless otherwise indicated.
   B. Grounding Conductors:
      1. Equipment Grounding Conductor: Green insulated. Conductors No. 4 and larger may use green taped conductor ends.
      2. Grounding Electrode Conductor: Bare stranded, soft drawn or soft annealed, copper wire.
         a. Bury at least 24 inches (600 mm) below grade.
         b. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
4. Isolated Ground Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

C. Bonding Conductors:
1. Bonding Conductor: No. 4 or 6 AWG, stranded conductor.
2. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
3. Tinned Bonding Jumper: Tinned copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.5 EQUIPMENT ROOM GROUND TERMINAL BAR
A. Copper 1/4 inch thick by 4 inch wide by length shown on Drawings, unless otherwise indicated, with two (2) rows of predrilled holes on 1-1/2 inch centers for 1/2 inch bolt, to receive cables from two (2) directions. Stand-off insulators for mounting shall be listed for the application, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.6 CONNECTORS
A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure type, with at least two bolts.
   1. Pipe Connectors: Clamp type, sized for pipe.
   2. Split-bolt connectors shall not be used for any application.
C. Molded Fusion Welded Connectors: Exothermic welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
D. Irreversible Compression Connectors: Mechanical compression tool and die kits of types recommended by kit manufacturer for materials to be joined and installation conditions.

2.7 GROUNDING ELECTRODES
A. Ground Rods: Copper clad steel with high strength steel core and electrolytic grade copper outer sheath, molten welded to core.
   1. Size: 3/4 inch diameter by 10 feet.
B. Ground Test Station: Fabricate from 15-inch (400 mm) long, square cut sections of 8 inch (200 mm) diameter, Schedule 80, PVC pipe.

PART 3 - EXECUTION

3.1 GENERAL
A. Ground all equipment, furnished by this Division or by others.
   1. Split-bolt connection methods shall not be used.
B. Provide building grounding as shown on Drawings.

C. Provide ground connection for electric service and/or generator system as shown on Drawings.

D. Provide ground connection for electric service and generator system as shown on Drawings.

E. All transformer enclosures and secondary neutrals shall be separately grounded to a separate ground electrode with a continuous grounding electrode conductor sized per NEC. Do not ground directly to building steel. Refer to Single Line Diagram and details on drawings.

F. Make molded fusion welds and irreversible compression connections in strict accordance with supplier's instructions. Clamp cables securely in place, independent of connection. Clean and inspect all connections.

G. At least one connection shall be made between the building ground, the electrical service ground for the building, and a metallic cold water pipe ground larger than 1 inch trade diameter.

H. Grounding cable shall not be buried directly in concrete, but a grounded metallic or non-metallic conduit sleeve shall be provided where cable passes through concrete.

I. Where ground conductors are shown on Drawings and for all feeders, the use of the metallic raceway in place of the ground conductor shall not be permitted. Provide grounding bushings (or other approved devices such as bonding-type locknuts or bushings) at each end of all low voltage and medium voltage feeder raceways. Where non-metallic conduit is used, coordinate the installation of a code sized ground conductor.

J. All grounding conductors run inside the building shall be run within NEC sized metallic raceways with raceway grounding bushings at each end and bonding jumper to the enclosure or ground bus. Extend raceway to associated equipment enclosures and to within 6 inches of exposed ground terminal bar installations. Raceway installations shall be in accordance with Division 26 Section "Raceways."

1. Each ground conductor bus connection shall be terminated with individual compression lug and associated individual lug bolt.

2. Split-bolt connection methods shall not be used for any application.

K. Welded connections may have multiple ground conductors to suit mold and may be considered "continuous."

3.2 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic welded or irreversible connectors for outdoor locations. Only when a disconnect type connection is indicated, use a bolted clamp.

D. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each above ground portion of gas piping system downstream from equipment shutoff valve.

E. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

3.3 BUILDING GROUNDING INSTALLATIONS
A. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart as shown on Drawings.
B. Building Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod extending around the perimeter of building.
   1. Install copper conductor not less than No. 3/0 AWG for ground ring and for taps to building steel.
   2. Bury ground ring not less than 30 inches (762 mm) from building foundation.
C. Concrete Encased Grounding Electrode: Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.
   1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.
   2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

3.4 UNDERGROUND INSTALLATIONS
A. Comply with IEEE C2 grounding requirements.
B. Drive ground rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
C. Drive ground rods to a minimum depth of ten feet, or more if necessary to reach permanent moisture. Ground rods shall be driven at least 2 feet away from the footing.
D. Underground Grounding conductors:
   1. Bury at least 24 inches (600 mm) below grade.
   2. Interconnect new and existing ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
   3. Duct Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct bank installation.

E. Perform all connections below grade with exothermic welds or irreversible compression connections. Provide corrosion protection in acid soils.

F. Ground Test Station: Set top of well flush with finished grade or floor. Fill with 1-inch- (25-mm-) maximum size crushed stone or gravel to 1 inch below rod ground cable weld.

3.5 SEPARATELY DERIVED SYSTEMS GROUND RING INSTALLATIONS

A. Ground ring: Install at least (3) ground rods spaces one rod length from each other and located at least the same distance from other grounding electrodes, and interconnect with exothermic welds to the system grounding electrode conductor using minimum #3/0 bare copper conductor.

B. Provide ground ring for the following separately derived systems:
   1. Electrical Services: The facility service transformer ground ring serves as the electrical service ground ring.
   2. Generator System: Connect to each generator equipment grounding conductor and to each generator frame.
   3. Photovoltaic System.

3.6 EXTERIOR PAD MOUNTED ELECTRICAL ASSEMBLY GROUNDING INSTALLATIONS

A. Ground ring: Install at least (4) ground rods at each pad corner with ground ring buried not less than 6 inches (150mm) around the pad and interconnect with exothermic welds to the equipment grounding electrode conductor using minimum #3/0 bare copper conductor.

B. Provide ground ring for the following exterior pad mounted electrical assemblies:
   2. Transformers.
   3. Switchgears.
   4. Substations.
   5. Generator System: Connect to each generator equipment grounding conductor and to each generator frame.

3.7 ELECTRIC SERVICE AND TRANSFORMER GROUNDING INSTALLATIONS

A. Make grounding connections electrically ahead of any overcurrent or disconnect device or tap connection such that disconnection of neutral load conductors does not interfere with or remove the system ground connection. Use separate lugs on the transformer neutral terminal for neutral and main grounding jumper when cable is used for transformer connections.

B. Connect low voltage transformer grounds to an Equipment Room Ground Terminal bar if located in the same room and provided with an adequately sized common grounding electrode conductor; otherwise connect to the nearest accessible structural steel member or other grounding electrode as permitted by the NEC.

GROUNDING AND BONDING 260526 - 7

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3.8 EQUIPMENT ROOM GROUND TERMINAL BAR INSTALLATION

A. Install a complete grounding electrode system with interconnecting cables and terminations at electrical and communications equipment rooms.

B. Install ground terminal bar in equipment rooms where shown on Drawings. Mount bar by anchors and bolts using 1-1/2 inch long insulated spacer between bar and wall. Use a minimum of two (2) supports 18 inch on center. Connect all grounding electrode system conductors, system enclosure ground bus, and other indicated electrode systems to the terminal bar.

3.9 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING INSTALLATIONS

A. General:
   1. Provide continuous equipment grounding conductor system for underground distribution.

B. Concrete Duct Banks:
   1. Install a minimum #3/0 bare copper wire in new concrete duct banks of two or more conduits. Provide the ground wire near the bottom loosely laid in the duct bank without tension, held in place to the bottom of a raceway with tape, and not supported by or in contact with rebar, steel wires, or other metal.
   2. Leave long in manholes and pullboxes to reach their ground bus without splice.

C. Manholes (Handholes are synonymous):
   1. Install a driven ground rod through the floor close to wall setting ground rod depth so 4 inches (100mm) will extend above finished floor. Protect ground rods passing through concrete floor with a double wrapping of pressure sensitive insulating tape or heat shrink insulating sleeve from 2 inches (50mm) above to 6 inches (150mm) below concrete. Seal floor opening with waterproof, nonshrink grout.
   2. If necessary, install ground rod before manhole is placed and provide a minimum #3/0 bare copper conductor exothermic welded from ground rod into manhole through a waterproof sleeve in manhole wall.
   3. Manhole Cable Bus: Support a minimum #3/0 bare copper conductor around inside perimeter of manhole 2 feet above finished floor and exothermic weld to ground rod or ground rod conductor and concrete duct bank ground conductors entering manhole.
   4. Manhole Components Grounding: Bond exposed metal parts, such as inserts, cable racks, pulling irons, sump frame, manhole cover frame, and ladders within each manhole with minimum #6 bare copper wire to associated manhole cable bus with exothermic weld. Train conductors level or plumb around corners and fasten to manhole walls.

D. Medium Voltage Cable Raceway Applications:
   1. Bond medium voltage cable splice and terminating kit shields per manufacturer’s instructions to associated manhole cable bus with exothermic weld.
   2. Install grounding bushing on all metallic raceways entering buildings, manholes, or vaults, and extend grounding conductor to each associated manhole cable bus and building wall pullbox ground bus.

E. Low Voltage Electrical Power Conductors and Cables Raceway Applications:
1. Install grounding bushing on all metallic raceways entering buildings, manholes, or vaults, and extend grounding conductor to each associated manhole cable bus and building wall pullbox ground bus. Where non-metallic raceways are used as part of the feeder raceway extension, also extend the grounding conductor through the entire raceway.

3.10 TELECOMMUNICATIONS SIGNAL GROUNDING SYSTEM INSTALLATION

A. Definitions:
1. TBB: Telecommunications Building Backbone.
2. TGB: Telecommunications Grounding Busbar.
3. TMGB: Telecommunications Main Grounding Busbar.

B. Install a complete telecommunications grounding electrode system with room grounding buses, grounding electrodes, and interconnecting cables per ANSI/EIA/TIA-607A.

C. Install main and room ground busbars at 18 inches AFF. Mount busbar by anchors and bolts using 1-1/2 inch long insulated spacer between bar and plywood. Use a minimum of two (2) supports for each busbar.

1. Provide signal ground (TBB) homeruns from the TMGB to the furthest (highest) TGB in each group of stacked telecom rooms with grounding conductor in conduit. Sleeves may be utilized to pass through telecom rooms in lieu of conduit. Bond conduit at each end to the local TGB.
   a. TBB shall be routed through each telecom room in route to the highest TGB in each vertical of stacked telecommunications rooms. Determine the TBB conductor size (diameter) by its final length from TMGB to furthest TGB approximately 2kc mils per linear foot. Refer to chart in PART 3.
   b. Connect each TGB to TBB in each TR with a maximum 8 inch copper grounding whip with irreversible connection. Size (diameter) whip one gage smaller than that of TBB.

2. Lug main grounding bus to grounding electrodes with No. 1/0 grounding electrode conductor per Division 26 Section "Grounding and Bonding."

3. Provide a Bonding Conductor (BC) terminated at the TMGB and the electrical service ground bar. Size similar to a TBB.
   a. Determine the size (diameter) of the BC by its final length, approximately 2kc mils per linear foot. Refer to chart in PART 3. Provide size equal to or greater than the diameter of the longest TBB.

D. Provide a Grounding Equalizer (GE) bonding each TGB to all other TGBs on every third (3rd) floor (and at top floor) of buildings with multiple stacked telecommunications rooms.

1. The GE shall be continuous and extend from a TGB in the Telecommunications Room to each TGB in Telecommunications Rooms on the same floor.
2. Determine the GE size (diameter) by its final length, approximately 2kc mils per linear foot. Refer to chart in PART 3. Provide size equal to or greater than the diameter of the longest TBB.

E. Telecommunications Ground Ring: Provide an exterior service entrance grounding electrode system specific to telecommunications system.

1. Install three (3) ground rods equidistant from each other (minimum of 6 feet).
2. Extend a BC to TMGB from one ground rod.
   a. Determine the size (diameter) of the BC by its final length, approximately 2kc mils per linear foot. Refer to chart in PART 3. Provide size equal to or greater than the diameter of the longest TBB.

F. Provide TBB from TMGB to Equipment Room Ground Terminal Bar. Size TBB one size larger than longest TBB in building.

G. Label each telecommunications bonding conductor as close as practicable to its point of termination in a readable position, "IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED, PLEASE CALL THE BUILDING TELECOMMUNICATIONS MANAGER".

H. Provide ground connection to anti-static floor where required.

I. Install room terminal ground bus directly adjacent to main and room ground buses at 18 inch AFF. Tie to room ground bus with bare No. 1/0 AWG.

J. Bond metallic telecommunications pathways (e.g. conduit, sleeves, cable trays, fire rated assemblies, etc.) to ground. Use structural steel where available. When a bonding conductor is installed in metallic conduit, bond the bonding conductor to the conduit at both ends.

K. All exterior/underground terminations shall be made with exothermic welds or irreversible compression connectors.

L. Measure impedance of grounding conductors upon completion and record on as-built documents.
M. Size all Telecommunications Signal Bonding Conductors per the following schedule:

### INSULATED GROUNDING CONDUCTOR SIZING SCHEDULE

<table>
<thead>
<tr>
<th>CONDUCTOR LENGTH (FEET)</th>
<th>INSULATED CONDUCTOR SIZE (AWG)</th>
<th>MAXIMUM AREA (CIRCULAR MILS)</th>
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1. **DESIGN GUIDE BASIS:**
   - A. MAXIMUM VALUE OF 0.1 OHM AT EACH POINT
   - B. 2K CIRCULAR MILS NEEDED FOR EVERY FOOT
   - C. NEC TABLE 8

2. **MINIMUM REQUIREMENTS:**
   - A. EQUIPMENT GROUND CONDUCTOR: 6 AWG (MIN.)
   - B. TELECOMMUNICATIONS BUILDING BACKBONE (TBB: 2 AWG (MIN.))

### 3.11 ELECTRICAL EQUIPMENT GROUNDING CONDUCTOR INSTALLATIONS

A. Unless indicated otherwise, form one equipment ground circuit with rigid metallic raceways (e.g. EMT, rigid steel conduit) where used. Install a bonding jumper for continuity around all fittings and terminations where the conductive raceway is made non-continuous (i.e. underground feeder non-metallic raceways).

1. Bond all grounding conductors to boxes or enclosures at each access point utilizing approved grounding kits. Do not use building steel as equipment grounding path.
2. Bond all conductive metallic piping system in each mechanical equipment room as required by NEC utilizing approved clamps. Minimum size of conductors as required by NEC. Locate all connections where access is unrestricted for inspection. Looping of conductor from one system to another is acceptable provided the conductor is without splice and has each end of loop bonded.

B. Provide, in the same raceway with the associated phase and/or neutral conductors, a green colored equipment ground conductor having the same type insulation and connected as described below to provide equipment ground redundancy.

1. Install a ground conductor in each raceway to augment the circuit formed by the metallic raceway system. Bond the conductor to each box or enclosure in which access is possible utilizing enclosure equipment ground kits, through metallic conduit insulated ground bushings or wedges and/or enclosure threaded grounding studs. Size conductor as specified, shown or required by Code, whichever is larger. Install a raceway grounding bushing and bonding jumper to the enclosure or contained ground bus for the following: each termination of conduits 1 inch trade size and larger at a switchboard, panelboard, or other enclosure, each location where multiple ring knockouts are damaged during conduit installation, each location where conduits are stubbed up into floor mounted enclosures; each conduit termination at a painted enclosure where paint is not removed before installation of raceway and each feeder.

   a. All branch circuits shall be provided with an equipment grounding conductor sized per NEC Table 250-122. This includes all lighting and power branch circuits.
   b. Provide a ground conductor to all light switches, receptacles, motors, light fixtures and all other branch circuit loads.
   c. Install a ground conductor inside all flexible raceways (e.g., flexible steel, liquid tight). Bond the conductor to the enclosure or ground bus in the nearest box or access on either side of the flexible section. Size conductor as specified, indicated, or required by Code, whichever is larger.
   d. Install a ground conductor in all sectional raceways with removable covers for access (e.g. plug-in strips, surface raceway systems, and wireways) unless specified otherwise. Size conductor in accordance with the NEC for the largest phase conductor size installed in raceway, or as indicated. Bond all sections of the raceway to the ground conductors. Connect all receptacle ground terminals in the raceway to the ground conductor, and make other ground connections shown on Drawings.

C. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

D. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
E. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.


2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

F. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch circuit conductors.

3.12 SURGE PROTECTION DEVICE PROTECTION DEVICE (SPD) GROUND CONDUCTOR INSTALLATIONS

A. Extend separate transient voltage surge suppressor dissipation ground conductors to local equipment ground bus and to common grounding electrode conductors. Size conductors per (SPD) manufacturer recommendations and National Electrical Code. Refer to details on Drawings.

3.13 HEALTHCARE EQUIPOTENTIAL GROUNDING

A. Installation:

1. Patient Care Area: Extend #10 insulated grounding wiring from patient reference ground points to each patient area device shown on Drawings as well as any other fixed conductive surfaces in patient vicinity likely to become energized.

   a. Wiring may be run outside or within branch circuit raceway (limited to one) if in proximity. Bundle individual grounds together and run parallel to walls and floors for a workmanship like installation.

2. Panelboard Bonding: Provide a #10 insulated, continuous copper conductor between the grounding terminal bars in each panelboard serving the same individual patient care vicinity.

B. Testing:

1. Measure the potential between the grounding pole of one receptacle and the grounding pole of all other receptacles. Measured potential shall not exceed 20 millivolts with the electrical system both energized and de-energized.

   a. Contractor shall provide a written report of each low voltage service that it does not exceed 0.1 ohms. Reference NFPA 99. Test report shall be available on site at inspection. Ground resistance shall be measured by suitable, ground resistance test equipment which shall be available on site, at inspections, to verify at sample locations.

   b. Measure the potential between the grounding pole of one receptacle and the grounding pole of all other receptacles. Measured potential shall not exceed 20 millivolts with the electrical system both energized and de-energized. Reference NFPA 99.

   c. Record ground resistance from every grounded metal object and ground jack to associated patient ground point using ground integrity tester.

GROUNNING AND BONDING

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d. Record potential between every grounded metal object and ground jack in patient vicinity with nearby branch circuits energized, using ground integrity tester.
e. Correct all unacceptable measurements.

3.14 LABELING
A. Comply with requirements in Division 26 Section "Electrical Identification" for instruction signs. The label or its text shall be green.
   1. Install labels on bonding conductor or on bonding conductor raceway every 15 feet. Identify system/service and bonding termination locations.
B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.

3.15 FIELD QUALITY CONTROL
A. Tests and Inspections:
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS "Grounding Systems" requirements and the following additional requirements:
      a. Prepare dimensioned Drawings locating each test well, ground rod, and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
      b. Grounding system will be considered defective if it does not pass tests and inspections.
      c. Prepare test and inspection reports.
   2. Report measured ground resistances that exceed the following values:
      a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
      b. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
      c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
      d. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
      e. Substations: 5 ohms.
   3. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526
SECTION 260529 - HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

B. Provide bases, inertia pads, steel supports, anchor bolts, inserts, etc., for all equipment and apparatus shown on Drawings.

C. Floor mounted electrical equipment shall be installed on 4 inch high floor doweled concrete housekeeping pads with equipment inset 4 inches on all sides. Concrete shall be in accordance with referenced concrete specification section.

D. Solidly anchor steel support channel framework to floor and ceiling slabs and mount the designated equipment thereto.

E. Provide concrete pads for floor mounted equipment such as:
   1. Central Battery Inverter Systems.
   2. Distribution type panelboards when installed below six inches above floor.
   3. Floor Mounted Automatic Transfer Switches.
   4. Load Intermittent Switches.
   5. Switchgear Assemblies.
   6. Transformers.
   7. Unit Substations.
   8. UPS Systems.

F. Provide steel support channels for wall mounted equipment such as:
   2. Communication and Special Systems Cabinets.
   3. Disconnect Switches.
   5. Individual Motor Controllers.
   8. Panelboards.
   9. Raceways.
   10. Wall Mounted Transformers.

G. Coordinate and provide concrete pads under wall mounted equipment installed six inches or less from the floor. Provide consideration for maximum protective device height on larger distribution panelboards.

H. Related Sections include the following:
   1. Division 26 Section "Vibration Controls" for products and installation requirements necessary for compliance with vibration criteria.
1.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements".

1.4 ACTION SUBMITTALS

A. Product Data:
   1. Trapeze hangers.
   2. Steel slotted support systems.

B. Shop Drawings:
   1. Show fabrication and installation details and include calculations for the following:
      a. Trapeze hangers.
      b. Steel slotted channel systems.
      c. Equipment supports.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Comply with NFPA 70.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

HANGERS AND SUPPORTS

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PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allied Tube & Conduit, a Division of Tyco.
      b. Line Systems.
      c. Cooper B-Line, Inc.; a Division of Cooper Industries.
      d. ERICO International Corporation.
      e. GS Metals Corporation.
      f. Thomas & Betts Corporation.
      g. Unistrut; Tyco International, Ltd.
      h. Wesanco, Inc.
   2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
   3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
   4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
   5. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
   1. Support device accessories used in exterior or wet locations shall be corrosion resistant hot dip galvanized steel or stainless steel.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
   1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
      a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Hilti, Inc.
         2) ITW Ramset/Red Head; a Division of Illinois Tool Works, Inc.
3) MKT Fastening, LLC.
4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, steel, for use in hardened Portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
   a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Cooper B-Line, Inc.; a Division of Cooper Industries.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti, Inc.
      4) ITW Ramset/Red Head; a Division of Illinois Tool Works, Inc.
      5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.

4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.

5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

6. Toggle Bolts: All-steel springhead type.


G. Hangers, supports, and associated fittings for exterior applications or parking structures shall be hot-dip galvanized steel and/or stainless steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with NEC, NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Take care not to weaken concrete or penetrate waterproofing where equipment supports are on concrete construction.

C. Obtain prior approval for installation method where structural steel is required to frame into building structural members for the support of equipment, conduit, etc. Welding is permitted only when approved by Engineer’s field representative.

D. Coordinate with the building structural system and with other electrical installation.
   1. Metal Decking: Nothing is to be suspended from steel roof decks (no concrete).
E. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel or angle iron racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

F. In overhead spaces, boxes shall be supported independently of raceways and raceways independent of the boxes. Support boxes directly from the building structure or by bar hangers.
   1. Where bar hangers are used for boxes, attach the bar to raceways on opposite sides of the box and support the raceway with an independent approved type of fastener not more than 24 inches from the box. To clarify, box or raceway removal should not require re-supporting of the other.

G. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

H. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
   1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

I. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NEC, NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structural members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
   1. To Wood: Fasten with lag screws or through bolts.
   2. To New Concrete: Bolt to concrete inserts.
   3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   4. To Existing Concrete: Expansion anchor fasteners.
   5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
   6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
7. To Light Gage Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS
A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES
A. Coordinate dimensions of concrete housekeeping pads with requirement for equipment supplied.
B. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
   1. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."
   2. Drill and grout steel reinforcing bar dowels to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
C. Anchor equipment to concrete base:
   1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install epoxy coated anchor bolts to elevations required for proper attachment to supported equipment.
   3. Install anchor bolts according to anchor bolt manufacturer's written instructions.

3.5 PAINTING
A. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529
SECTION 260533 – RACEWAYS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes raceways for electrical wiring. Types of raceways in this Section include the following:
   1. Rigid galvanized steel conduit (RGS).
   2. Intermediate metal conduit (IMC).
   3. Electrical metallic tubing (EMT).
   4. Rigid aluminum conduit.
   5. PVC externally coated rigid conduit.
   6. Rigid nonmetallic conduit (RNC).
   7. Flexible metal conduit.
   8. Liquidtight flexible metal conduit.
   9. Conduit bodies.
  10. Conduit fittings.
  11. Surface raceways.
  12. Wireway and auxiliary gutters.
  13. Steel wall duct.

1.2 SEQUENCING AND SCHEDULING
A. Coordinate with other Work, including metal and concrete deck installation, as necessary to interface installation of electrical raceways and components with other Work.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: For surface raceways and all conduit fittings only.
B. Shop Drawings:
   1. Layout Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.
      a. Structural members in the paths of conduit groups with common supports.
      b. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.
      c. Include plans, elevations, sections, details and attachments to other work.

1.5 CLOSEOUT SUBMITTALS
A. Record Documents.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

B. Rigid Metallic Conduit:
   1. Allied, a Division of Tyco.
   2. Republic Conduit.
   3. Wheatland Tube Co.

C. Rigid Aluminum Conduit:
   1. Allied, a Division of Tyco.
   2. Alumax.
   3. New Jersey Aluminum.
   4. VAW Aluminum.

D. PVC Coated Rigid Conduit and Fittings:
   1. Calpipe
   2. Ocal, a Division of Thomas and Betts.
   3. Perma-Cote Industries.

E. Rigid Nonmetallic Conduit and Fittings:
   1. Allied, a Division of Tyco.
   2. Can-Tex.
   3. Carlon.
   5. IPEX.

F. Flexible Nonmetallic Conduit and Fittings:
   1. Arnco Corporation.
   2. Endot Industries, Inc.
   3. Carlon Plenum-Guard.
   4. Kwikpath, IPEX, Inc.

G. Flexible Metal Conduit and Fittings:
   1. AFC Cable Systems, a Division of Tyco.
   2. Al-flex (Steel).
   3. Liquatite.

H. Liquidtight Flexible Metal Conduit and Fittings:
   1. AFC Cable Systems, a Division of Tyco.
   2. Al-flex.
   3. American Flexible Conduit.
   4. Anamet, Inc.
   5. Electro Flex.
7. PDU Cables.
8. RACO.

I. Conduit Bodies:
   1. Appleton Electric Co.
   2. Carlon (PVC).
   3. Crouse-Hinds Division, Cooper Industries, Inc.
   5. O-Z/Gedney.

J. Conduit Fittings:
   1. Allied, a Division of Tyco.
   5. Midwest Electric.
   7. RACO.
   8. Steel City.
   9. Thomas and Betts.

K. Wireways and Auxiliary Gutters:
   2. Lee Products Co.
   3. Walker-Parkersburg.

L. Surface Metallic Raceway:
   1. Hubbell, Inc. 3000 and 4800 series and ALU3800 and ALU4800 series.
   2. The Wiremold Co. G3000, AL3100, and G4000 series; or Div. of Legrand.

M. Steel Wall Duct:
   1. Mono-Systems.
   2. Nova
   3. Square D.
   4. Wiremold.

N. Aluminum Surface Raceway:
   1. As fabricated by local fabricators.
   3. Nova

O. HDPE Conduit:
   1. Blue Diamond
   2. Carlon
   3. Dura-line
2.2 REGULATORY REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

C. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.

1. National Electrical Manufacturers Association (NEMA):
   a. NEMA, FB1  Fittings for Metallic Conduit
   b. NEMA, RN 1  PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
   c. NEMA, TC2  Schedule 40 and Schedule 80 PVC
   d. NEMA, TC 3  PVC Fittings for Use with Rigid PVC Conduit and Tubing

   a. ANSI-C80.1  Rigid Steel Conduit
   b. ANSI-C80.2  Rigid Steel Conduit, Enamed
   c. ANSI-C80.3  Electrical Metallic Tubing, Zinc-coated
   d. ANSI-C80.5  Rigid Aluminum Conduit
   e. ANSI-C80.6  Intermediate Metal Conduit (IMC)

   b. ASTM F 52160  Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit based on Controlled Outside Diameter (OD)

D. UL Compliance and Labeling: Comply with applicable requirements of UL standards pertaining to electrical raceway systems. Provide raceway products and components listed and labeled by UL, or ETL:

   1. UL 1  Flexible Metal Electrical Conduit
   2. UL 5  Surface Metal Electrical Raceways and Fittings
   3. UL 6  Rigid Metal Electrical Conduit
   4. UL 360  Liquidtight Flexible Steel Conduit, Electrical
   5. UL 514B  Fittings for Conduit and Outlet Boxes
   6. UL 651  Schedule 40 and 80 PVC Conduit
   7. UL 797  Electrical Metallic Tubing
   8. UL 870  Electrical Wireways, Auxiliary Gutters, and Associated Fittings
   9. UL 1242  Intermediate Metal Conduit

2.3 METAL CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit: ANSI C80.1.

B. Intermediate Steel Conduit: UL 1242.

C. PVC Externally Coated Rigid Steel Conduit and Fittings: ANSI C80.1 and NEMA RN 1.
D. Electrical Metallic Tubing and Fittings: ANSI C80.3.
E. Rigid Aluminum Conduit: ANSI C80.5.
F. Flexible Metal Conduit: UL 1, zinc-coated steel.
G. Liquidtight Flexible Metal Conduit and Fittings: UL 360. Fittings shall be specifically approved for use with this raceway.
H. Provide manufacturer colored conduit where available for conduit less than 2-1/2", otherwise conduit shall be painted. Refer to Division 26 Section "Electrical Identification" for specified colors per system.

2.4 NONMETALLIC CONDUIT AND DUCTS
A. Rigid Nonmetallic Conduit: NEMA TC 2 and UL 651, Schedule 40 or 80 PVC.
B. PVC Conduit and Tubing Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.
C. HDPE Conduit: NEMA TC 3 and UL 651A, Schedule 40 or 80.
D. Conduit and Duct Accessories: Types, sizes, and materials complying with manufacturers published product information. Mate and match accessories with raceway.

2.5 CONDUIT BODIES
A. General: Types, shapes, and sizes as required to suit individual applications and NEC requirements for feeder runs only. Branch circuit use is prohibited. Provide matching gasketed covers secured with corrosion-resistant screws.
B. Metallic Conduit and Tubing: Use metallic conduit bodies. Use bodies with threaded hubs for threaded raceways. Use bodies with set screw or compression type hubs for EMT according to fitting application specified below.
C. Nonmetallic Conduit and Tubing: Use nonmetallic conduit bodies conforming to UL 514 B.

2.6 CONDUIT FITTINGS
A. General: Types, shapes, and sizes as required to suit individual applications and NEC requirements. Die cast fittings are not acceptable.
B. Rigid Galvanized Steel, Intermediate Steel and Rigid Aluminum Conduit: Use threaded type with bushed connections only, unless otherwise approved in writing by engineer. Factory-installed conduit couplings are acceptable.
C. Electrical Metallic Tubing Conduit: Use nylon insulated fittings. Steel body or integral conduit sleeve dual double set-screw type fittings are acceptable for EMT conduits except for kitchens and damp locations where threaded compression types are required. Die cast fittings are not acceptable.
1. Nylon fittings may be eliminated if rounded box teeth type fitting are used (i.e. Cooper Crouse Hinds Space Saver).
2. Colored fittings may be used for conduit 2-1/2" and larger to meet raceway identification requirements of Division 26 Sections "Boxes and Cabinets" and "Electrical Identification."
D. Rigid Nonmetallic Conduit: Use fittings designed specifically for conduit type of same manufacturer.

E. Flexible Metal Conduit: Use nylon insulated throats of the following type:
   1. Wedge and screw type.
   2. Squeeze on clamp type with one or two screws.
   3. Steel multiple-point type for threading into internal wall of conduit.

F. Liquidtight Flexible Conduit: Use threaded grounding cone with steel compression ring and tightening gland, steel body with insulated throat.

G. Unlike Conduit: Use connectors which meet individual conduit fittings requirements for both and are UL listed and labeled for such use.

H. Expansion and Deflection Fittings:
   1. Conduit movement in straight line direction:
      a. O-Z/Gedney type AX series.
      b. Crouse-Hinds (Eaton)
      c. Thomas & Betts (ABB)
   2. Up to 3/4 inch deflection and movement in all directions:
      a. O-Z/Gedney type DX series.
      b. Crouse-Hinds (Eaton)
      c. Thomas & Betts (ABB)
   3. Deflection and movement beyond 3/4 inch in all directions:
      a. O-Z/Gedney type AXDX series.
      b. Crouse-Hinds (Eaton)
      c. Thomas & Betts (ABB)
   4. PVC Expansion fittings:
      a. Allied
      b. Cantex
      c. Carlon

I. Conduit Bushings:
   1. Rigid Steel and Intermediate Steel Conduit: Threaded, grounded, insulating type with thermosetting or fiber insert in a metal body.
   2. Insulated Grounding Bushings or grounding wedges on metallic conduits shall be installed per Division 26 Section "Grounding and Bonding."
   3. Conduit Sleeves/Stubs: Nonmetallic insulated UL approved for air handling spaces when installed in air handling plenums.

J. Conduit Seals:
   1. Cast in place with pressure ring and sealing grommet:
      a. O-Z/Gedney type FSK series with FSKA membrane clamp adapter.
   2. Cast in place with two pairs of pressure rings and sealing grommets:
      a. O-Z/Gedney type WSK series.
3. For sealing conduits installed in core-drilled, sleeved, or precast holes:
   a. O-Z/Gedney type CSM series with CSMC membrane clamp adapter.
   b. Thunderline Link-Seal series.

2.7 SURFACE RACEWAYS

A. General: Sizes and channels as shown on Drawings. Provide fittings that match and mate with raceway.

B. Surface Metal Raceway: Construct of galvanized steel or extruded aluminum with snap-on covers, with 1/8-inch mounting screw knockouts in base approximately 8 inches o.c. Finish with manufacturer's standard prime coating suitable for finish paint selected by Architect. Provide wire clips as recommended by manufacturer for holding conductors in place.

C. Surface Metal Ducts: Construct of galvanized steel or extruded aluminum with snap-on covers, with 1/8 inch mounting screw knockouts in base approximately 8 inches o.c. with accessories as required to accomplish the arrangement indicated and NEC separation. Finish with manufacturer's standard prime coating suitable for finish paint selected by Architect. Provide wire clips as recommended by manufacturer for holding conductors in place. Provide wiring device in assembly as indicated.

1. Use the branch circuit equipment grounding conductor to bond each section where used for power wiring.

2.8 WIREWAYS AND AUXILIARY GUTTERS

A. General: Electrical wireways and auxiliary gutters shall be generally NEMA 1 construction of types, sizes, and number of channels as indicated. Fittings and accessories including but not limited to couplings, connectors, tees, offsets, elbows, expansion joints, adapters, hold-down straps, and end caps shall match and mate with wireway as required for complete system. Provide corrosion resistant phosphate primer and baked gray epoxy finish. Where features are not indicated, select to fulfill wiring requirements and comply with applicable provisions of NEC and NEMA standards.

B. Wireway covers shall be hinged type.

2.9 STEEL WALL DUCT

A. Sheet metal duct suitable for installation of diagnostic and treatment equipment cables; with removable covers, partitions and accessories as indicated or required by the equipment manufacturer's representative.

B. Size: As shown on diagnostic and treatment equipment manufacturer’s layout drawings.

C. The wall duct raceway (body and cover) shall be fabricated from 14-gauge galvanized steel. Galvanized steel shall be of a paintable finish, such that no further preparation except for normal cleaning will be required to paint the raceway.

D. Coverplate widths shall be equal to the body width when raceway is surface mounted and shall exceed the body by 2 inch when the raceway is flush mounted.

E. The wall duct raceway shall be furnished in standard 5 foot lengths. Each 5 foot length shall consist of one body and two 30 inch long coverplates. 18 inch lengths of raceway (with one coverplate) shall also be used when appropriate.
F. When necessary, field modifications shall be made to the product to insure compliance with the manufacturer’s layout drawings.

G. Accessories: Provide the necessary accessories as required to make a complete installation. Accessories shall include but not be limited to internal coupling angles, snap-in-place wire retainers and end closures.

H. A non-adjustable partition shall be provided to maintain separation of services.

I. Fittings: All tee, horizontal elbow, internal elbow, external elbow and vertical elbows shall be provided as required. These fittings shall be provided with tunneling to maintain separation of services. Transitions from wall duct to trench duct shall be provided as required. Other miscellaneous fittings shall be provided as required to conform to diagnostic and treatment equipment manufacturer’s layout drawings.

2.10 ALUMINUM SURFACE FLOOR DUCT

A. Description: A sheet metal duct suitable for installation of MRI cables; with removable covers and accessories as indicated or required by the equipment manufacturer’s representative.

B. Size: As shown on diagnostic and treatment equipment manufacturer’s layout drawing. Lengths as required to match MRI equipment manufacturer’s layout on Drawings.

C. Openings: Provide transitions to riser duct as necessary with grommet openings in coverplate as required to distribution cables to designated equipment.

D. Coverplate: Widths shall be equal to the body width.

E. Fabrication: Duct (body and cover) shall be fabricated from aluminum. Duct shall include a partition for separation of services. Compartment for power cables shall be 6 inches wide.

F. Fittings: All tee, horizontal elbow, external elbows and vertical elbows shall be provided as required. These fittings shall be provided with tunneling to maintain separation of services. Other miscellaneous fittings shall be provided as required to conform to MRI equipment manufacturer’s layout drawings.

G. Accessories: Provide the necessary accessories as required to make a complete installation. Accessories shall include but not be limited to coupling mechanisms and end closures.

PART 3 - EXECUTION

3.1 CONDUIT RACEWAY APPLICATION

A. Rigid Galvanized Steel Conduit:

1. May be used in:
   a. Interior locations.
   b. Direct contact with concrete.

2. Shall be used in:
   a. Exposed exterior locations.
   b. Exposed interior damp or wet locations.
   c. Hazardous locations.
   d. Medium voltage interior applications (throughout).
e. Within seven foot area around boilers, incinerators and other heat producing equipment.

f. Exposed interior locations where subject to physical damage.

B. Intermediate Metallic Conduit:
   1. May be used in:
      a. All applications noted for rigid galvanized steel conduit except hazardous locations.

C. Electrical Metal Tubing:
   1. May be used in:
      a. Concealed interior locations above ceilings, in hollow studded partitions and in the cores of concrete masonry unit partitions.
      b. Exposed interior locations where not subject to physical damage.
      c. Low voltage electric and communication room applications.

D. Rigid Aluminum Conduit:
   1. May be used in:
      a. Concealed interior locations above ceilings and in hollow studded partitions.
      b. Exposed interior locations where not subject to physical damage.
   2. Shall be used in:
      a. Special applications where magnetic conduit is not acceptable as shown on Drawings.

E. Coated Conduit:
   1. May be used in:
      a. Direct contact with earth.
   2. Shall be used in:
      a. In parking garages within 7ft of finished floor.
      b. Corrosive environments.
   3. Shall not be used in HVAC plenums.

F. (Schedule 80) Nonmetallic Conduit:
   1. May be used in:
      a. Direct contact with earth.
      b. Locations embedded in concrete.
   2. Shall not be used in HVAC plenums or to serve patient care areas.

G. (Schedule 40) Nonmetallic Conduit:
   1. May be used in:
      a. Direct contact with earth.
      b. Locations embedded in concrete.
2. Shall be used in:
   a. Parking garages above 7ft of finished floor.

3. Shall not be used in HVAC plenums or to serve patient care areas.

H. HDPE Conduit:
   1. May be used in:
      a. Direct contact with earth.
   2. Shall not be used for:
      a. Service feeders.
      b. Emergency feeders.
      c. Medium voltage applications.

I. Flexible Metal Conduit:
   1. May be used in:
      a. Four to six feet long lengths for final connection to luminaries.
      b. Steel studwalls between outlets and from outlet to rigid raceway leaving wall for a maximum of three feet.
         1) This is not allowed in patient care areas subject to NEC 517.13.
   2. Shall be used in:
      a. 18 inches to 22 inch long lengths to form a slack "U" between rigid raceway system and:
         1) Busway plug-in devices.
         2) Rotating equipment.
         3) Vibrating equipment.
         4) Equipment requiring adjustments in position.
         5) Transformers.

J. Liquid-tight Flexible Metal Conduit shall be used as specified for flexible metal conduit as follows:
   1. Shall be used in:
      a. Final connection to all laboratory equipment.
      b. Damp locations.
      c. Wet locations.
      d. 18 inch to 22 inch long lengths to form a slack "U" between rigid raceway system and motors.
   2. Shall not be used in HVAC plenums.

3.2 INSTALLATION

A. General: Install electrical raceways in accordance with manufacturer's written installation instructions, applicable requirements of NEC, NECA1, and as follows:
   1. Provide power and wiring raceways to control devices for equipment by this or other Divisions.
2. Minimum conduit raceway size shall be 3/4 inch except switch legs, which may be 1/2 inch and 3/8 inch flexible conduit may be use for final connection to luminaires.
3. Provide supports for raceways as specified elsewhere in Division 26 Section "Hangers and Supports."
4. Cut square, free of burrs due to field cutting or manufacture, and use bushings approved for use where necessary.
5. Increase conduit raceway size as required due to NEC conductor derating requirements and availability. Minimum feeder conductor sizes, based upon NEC Table 310.16 and 40 percent maximum conduit raceway fill, shall be as shown on Drawings. If raceway type altered, be responsible for associated feeder conduit raceway size per NEC to meet 40 percent maximum fill.

B. Raceway Routing:

1. Separate normal power and generator powered conductors branch circuits, and feeder raceways in separate enclosures and rooms. Do not extend generator powered conductors and feeder raceways through normal power electrical rooms except where shown on Drawings or approved by the Electrical Engineer.
2. Conceal in finished rooms except where exposure is clearly indicated. Provide stainless steel escutcheon plates for all exposed finished wall, floor, and ceiling penetrations.
3. Install raceways exposed in mechanical and electrical equipment rooms and electrical closets. Maintain a minimum 7 ft. head room.
4. Install raceways parallel and perpendicular to nearby surfaces or structural members and follow the surface contours as much as practical.
5. Run exposed, parallel, or banked raceways together. Make bends in parallel or banked runs from the same center line so that the bends are parallel. Factory elbows may be used in banked runs only where they can be installed parallel. This requires that there be a change in the plane of the run such as from wall to ceiling and that the raceways be of the same size. In other cases provide field bends for parallel raceways.
6. Route raceways as required by job conditions unless dimensioned positions are shown on Drawings. Verify exact locations of all raceways, pull boxes, and junction boxes; resolve any conflicts before installation. Give priority in available space to large steam mains, steam lines that pitch, waste lines, drain lines, large air ducts, and all structural steel, unless indicated otherwise.
   a. Maintain raceway and box separations per NEC.
7. Elevation of Raceway: Where possible, install horizontal raceway runs above water and steam piping.
8. Make bends and offsets so the inside diameter is not effectively reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel. Bends shall exceed minimum bending radii of wire and cable to be run within.
9. Install with not more than three 90 degree bends or more than 100 feet of straight branch circuit conduit between pull boxes. Provide and install all additional pull boxes to meet this requirement.
10. Minimum Spacing: 3 inches between raceways and cold or hot water or waste piping, and 12 inches between raceways and parallel steam pipes and condensate pipes.
11. Do not place raceway less than one inch apart where they cross each other.
12. Install to provide adequate grounding between all outlets and the established electrical system ground.
13. Install to prevent water pockets.
14. Make no horizontal raceway runs in masonry walls.

C. Raceway Installation:

1. Prevent foreign matter from entering raceways by using temporary closure protection.
2. Protect stub-ups from damage where conduits rise from floor slabs. Arrange so curved portion of bends is not visible above the finished slab.
3. Raceways embedded in slabs:
   a. Refer to Division 03 Section "Cast-in Place Concrete" for limitation on placement of conduit in concrete.
   b. Tie raceways to reinforcing rods or otherwise secure them to prevent sagging or shifting during concrete placement.
   c. Maximum trade size of embedded conduit shall be 1 inch. Minimum spacing between conduits shall be 3 conduit diameters clear.
   d. Where conduit runs perpendicular to steel deck flutes, place conduit directly on steel deck. Where conduit runs parallel to steel deck flutes, place on 3/4 inch chair in low flute, with one conduit per flute maximum.
   e. Do not place conduit between reinforcing bars and concrete surface. Provide minimum 1-1/2 inch concrete cover over conduits.
   f. Do not lap or cross conduits at any point.
   g. Do not tie conduits to headed shear studs. Place conduits parallel to beams with headed shear studs at least 18 inches away from studs.
   h. Single conduit penetrations shall not be permitted in more than 3 consecutive deck flutes. Submit all variations to the Architect for review prior to the routing of conduits.
   i. Where nonmetallic conduit is used, raceways must be converted to rigid galvanized steel conduit or IMC before rising above floor. Refer to Division 26 Section "Grounding and Bonding." Nonmetallic conduit shall not be used for circuits within patient care areas.

4. When installed embedded in concrete, or, in direct contact with the earth:
   a. Provide rigid galvanized steel or IMC elbows for vertical rise through the concrete.
   b. Provide rigid galvanized steel or IMC conduit for the first ten foot section when leaving or entering a building.
   c. Make watertight with asphaltum or other approved compound applied to conduit joints before assembled.
   d. Refer to Section 3.1 for conduit applications in concrete or direct contact with the earth.

5. Join raceways with fittings and make joints tight. Use bonding jumpers as required to maintain electrical continuity of the raceway system for all metallic feeder conduits. Make raceway terminations tight. Where terminations are subject to vibration, use bonding bushings or wedges to assure electrical continuity. Use insulating bushings to protect conductors.

6. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished part against the box. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside the box.
7. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.
8. Complete installation of electrical raceways before starting installation of conductors within raceways.
9. Install a bonding wire in all flexible metal conduits.
10. Install pull wires in empty raceways. Use pulling line having not less than 200 lbs. tensile strength. Leave not less than 12 inches of slack at each end of the pull wire. Tag at each end identifying other end location.
11. Refer to Division 26 Section "Conduit Rough-In Systems" for special raceway installation requirements for telecommunications, systems (low-voltage, signaling systems) cabling.
12. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment with an adjustable top or coupling threaded inside for plugs and set flush with the finished floor. Extend conductors to equipment with rigid galvanized steel conduit; flexible metal conduit may be used 6 inches above the floor. Where equipment connections are not made under this contract, install screwdriver-operated threaded flush plugs with floor.
13. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceway is installed for such circuits and it passes through concrete, install in a nonmetallic sleeve.
14. Use rigid aluminum conduit in lieu of rigid galvanized steel only as permitted by code except where rigid galvanized steel conduit is specifically indicated. Comply with local codes governing the use and installation of aluminum conduit and fittings.
   a. Use aluminum accessories and fittings.
   b. Do not embed aluminum raceway systems in concrete or allow them to come in direct contact with poured concrete, concrete block construction, or earth.
   c. Comply with manufacturer's recommendations for bending, cutting, and threading operations.
   d. Use an approved aluminum lubricant at all couplings and threaded connections.
15. PVC externally coated rigid steel conduit: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduit.
16. If it is necessary to cut holes through webs of beams or girders, call such points to the attention of the Architect with size of hole before proceeding with work. All holes shall be cut no larger than absolutely necessary.
17. Whenever conduit is installed on exposed steel columns, the conduit shall be installed on the column web, and not on the flange.
18. All penetrations through existing floors shall be core drilled and sleeved.
19. All conduit knockouts or holes on electrical apparatus which are not used shall be provided with new plugs to match the NEMA rating of the enclosure.

D. Conduit Fittings:
1. Run with couplings approved for the conduit being used. Running threads and chase nipples will not be accepted in runs of threaded conduit.
2. Generally use mechanical dual set-screw type on EMT conduit except-use threaded compression type on EMT conduit within, kitchens, and damp locations.
3. Install grounding bushings per Division 26 Section "Grounding and Bonding."
E. Raceway Identification:
   1. Provide raceway identification per Division 26 Section "Electrical Identification."

F. Expansion-Deflection Fittings:
   1. Install in all raceways at the expansion joints of the building in such a manner that the expansion joints of the building will function properly and not stress any electrical raceways. Movement will be required in all directions. Refer to "A" Series Drawings for facility expansion joint locations.
   2. Maintain grounding continuity at each expansion-contraction fitting.

G. Conduit Seals:
   1. Use type "FSK" cast-in-place where conduit passes through foundation walls less than 60 inches below finished grade.
   2. Use type "WSK" cast-in-place where conduit passes through foundation walls at 60 inches or more below finished grade.
   3. Install watertight seals at all conduits passing through horizontal barriers. These seals may be types "FSK," "WSK," or "CSML." Sleeves shall extend at least two inches above the finished floor with 1/2 inch space around the conduit and this space sealed permanently watertight with a removable material (concrete not acceptable).
   4. Install where conduits pass through barriers having a 30 degree F or greater temperature differential in the spaces on either side at anytime, and in conduits entering or leaving supply and return air plenums. Install pliable removable plastic compounded in the nearest box at the top of vertical runs and at the hot end of horizontal runs.

H. Surface Raceways:
   1. Support with expansion shields, concrete inserts or masonry shields, as required for wall where wireway is mounted. Provide supports per code and manufacturer recommendations.

I. Surface Metal Raceways: Install a separate green ground conductor in raceway from the junction box supplying the raceway to receptacle ground terminals.

J. Wireways and Auxiliary Gutters:
   1. Support horizontally with expansion shields, concrete inserts or masonry shields, as required for wall where wireway is mounted. Provide supports per code.
   2. Provide at least 42 inch clear in front of all wireways with front covers.

K. Steel Wall Duct:
   1. Review the diagnostic and imaging equipment manufacturer’s installation drawings provided and become familiar with all components used. Wall duct shall be installed and used in accordance with appropriate National Electrical Code articles. Derating of power conductors as explained in the National Electrical Code shall govern. The maximum wire fill shall not exceed 40 percent of the interior cross sectional area of the wall duct.
   2. Mount wall duct with screws through the sides or back. Screws must be installed so the head of the screw is inside the wall duct body. Exposed threads are not permitted on the inside of the raceway. Overhead runs of wall duct may be mounted directly to structural members or hung via trapeze.
3. Install all wall duct, minus coverplates, before any wiring is placed in any portion of the system. Wall duct and fittings are to be assembled, minus coverplates, using couplings and screws provided by the manufacturer from the inside of the bodies.
4. Field drill coupling holes when necessary to field cut a straight length to suit conditions. Use the coupling as a template for proper hole placement. Do not enlarge diameter of coupling holes when field drilling duct body coupling holes.
5. Field install accessories such as partitions, etc., by match drilling holes in the duct body using holes in items as templates and installing self-tapping screws provided with each item.

L. Surface Aluminum Floor Duct:
   1. Review the MRI equipment manufacturer’s installation drawing provided and become familiar with all components used. Duct must be installed and used in accordance with appropriate National Electrical Code articles. The maximum wire fill shall not exceed 40 percent of the interior cross sectional area of the duct.
   2. Use flat-head screws to fasten channel to surfaces. Mount plumb and level.
   3. Install duct minus coverplates before any wiring is placed in any portion of the system.
   4. Use suitable insulating bushings and inserts at corners and cable exits.
   5. Maintain grounding continuity between raceway components to provide a continuous ground path.
   6. Fastener Option: Use clips and straps suitable for the purpose. Attach riser ducts to horizontal duct using manufacturer provided hardware.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS
   A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.4 FIRESTOPPING
   A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 PROTECTION
   A. Protect coatings, finishes and cabinets from damage and deterioration.
      1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
      2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

3.6 ADJUSTING AND CLEANING
   A. Upon completion of installation of raceways, inspect interiors of raceways; clear all blockages and remove burrs, dirt, and construction debris before installing or pulling conductors.

END OF SECTION 260533
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SECTION 260535 - BOXES AND CABINETS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section provides requirements and specifications for cabinets, boxes, and fittings for electric work, and electrical devices not covered in other sections. Products specified in this Section include:
   1. General Purpose Electric Work Boxes.
   2. Pull and Junction Boxes.
   3. Cabinets.

1.2 COORDINATION
A. Coordinate wall and floor box and cabinet penetration in rated walls with Division 07 firestopping installer to ensure rating is maintained.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic Divisions 26 Requirements."

1.4 ACTION SUBMITTALS
A. Shop Drawings:
   1. For the following raceway components. Include plans, elevations, sections, details and attachments to other work.
      a. Conduit fittings.
      b. Back to back recessed box or cabinet installation locations list, if any.

PART 2 - PRODUCTS

2.1 REGULATORY REQUIREMENTS
A. Listing and Labeling: Items provided under this section shall be designed, fabricated, and tested to Underwriter's Laboratories (UL) Standard 514A and 514C, and shall be so listed and labeled.
B. Federal Specifications: Items provided under this section shall comply with W-C-583b – Conduit Boxes and Outlet Fittings, Floor (for Rigid Conduit).
C. National Electrical Code Compliance: Components and installation shall comply with NFPA 70 "National Electrical Code."
D. NEMA Compliance: Comply with NEMA Standard 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)."
2.2 DESIGN CRITERIA

A. Electrical Boxes and Cabinets: Of indicated types, sizes and NEMA enclosure classes. Where not indicated, provide units of types, sizes and classes appropriate for the use and location. Provide all items complete with covers and accessories required for the intended use. Provide gaskets for units in damp or wet locations. Box depth shall exceed depth of installed device by 1/4 inch.

2.3 MATERIALS AND FINISHES

A. Sheet Steel: Flat-rolled, code-gage, galvanized steel.

B. Fasteners for General Use: Corrosion resistant screws and hardware including cadmium and zinc plated items.

C. Fasteners for Damp or Wet Locations: Stainless steel screws and hardware.

D. Cast Metal for Boxes, Enclosures and Covers: Copper-free aluminum except as otherwise specified.

E. Exterior Finish: Gray baked enamel for items exposed in finished locations except as otherwise indicated.

F. Painted Interior Finish: Where indicated, white baked enamel.

G. Fittings for Boxes, Cabinets and Enclosures: Conform to UL 514B. Malleable iron or zinc plated steel for conduit hubs, with ground terminal bushings and box connectors.

2.4 STEEL DEVICE BOXES

A. General:
   1. Fabricate from galvanized or cadmium plated pressed sheet steel, with installation provisions, brackets, hardware, etc., as required by the installation.
   2. Box depth shall exceed depth of installed device by 1/4 inch.
   3. Provide boxes complete with device covers, extension rings, ganged opening covers, etc., suitable for the application.

B. Switch Boxes:
   1. Single gang - 2 inch wide by 3 inch high by 2-1/2 inch deep minimum.
   2. Multi-gang - 4-inch high by 1-1/2 inch deep minimum by width as required by number of gangs.

C. Outlet, Receptacle, Device, and Junction Boxes:
   1. 4 inch square by 1-1/2 inch depth minimum, without clamps for either conduit or tubing.

D. Outlet Boxes (For Data/Communications/Systems Devices):
   1. 4 inch square x 2-1/8 inch deep galvanized sheet steel box.
      a. Provide not less than (6) 1 inch trade size knockouts in the 2-1/8 inch deep box.
      b. Box covers shall provide single or double gang finished openings, to match the specified device requirements, and shall be of depth and type required to provide a concealed, flush, installation in finished wall or ceiling construction.
2. Provide boxes with brackets and accessories suitable for installation in the specific wall or ceiling construction.

3. Boxes provided for open cabling and wiring installations (no raceways or conduits entering box) shall be provided with non-metallic bushings in the knockouts used for open cable entries and exits.

4. New outlets within non-rated accessible walls may be installed per the “ring and string” method consisting simply of a plaster mud ring with single gang device opening with pull string to accessible ceiling.

E. Wall and Ceiling Luminaire Boxes:
   1. Listed and identified for weight supported.

F. Acceptable Manufacturers:
   1. EGS/Appleton Electric.
   2. Cooper/Crouse-Hinds.
   3. Hubbell/Raco.
   4. Thomas & Betts/Steel City.
   5. Rand Industries, Inc.

2.5 CAST DEVICE BOXES
   A. General:
      1. Copper-free aluminum or malleable iron with matching cast cover.
   B. Switch Boxes:
      1. FS or FD series (or equivalent), single, two, multi-gang as required for wiring device arrangement.
   C. Outlet, Receptacle, Device, and Junction Boxes:
      1. FD series (or equivalent), single, two, multi-gang as required for wiring device arrangement.
   D. Acceptable Manufacturers:
      1. EGS/Appleton Electric.
      2. Cooper/Crouse-Hinds.
      3. Hubbell/Bell
      5. O-Z Gedney.

2.6 PULL AND JUNCTION BOXES
   A. General:
      1. NEMA type and size as required by area or as shown, complete with matching cover. Where necessary, gaskets shall be used to prevent entrance of moisture.
   B. Galvanized Sheet Steel:
      1. Minimum 14 gauge, solder or braze all seams, roll edges at openings and bolt on covers.

BOXES AND CABINETS
C. Cast Iron:
   1. Corrosion resistant, hot-dip galvanized and bolt on cast cover utilizing stainless steel screws.

D. Cast Aluminum:
   1. Non-rusting, non-sparking, non-magnetic and bolt on cast cover utilizing stainless steel screws.

E. Cast Bronze:
   1. Non-rusting, non-sparking, non-magnetic and bolt on cast cover utilizing brass screws.

F. Acceptable Manufacturers:
   1. O-Z/Gedney, a General Signal Co.
   2. Crouse Hinds; Div. of Copper Industries, Inc.
   3. Appleton Electric Co.
   5. Lee Products.
   7. Electromate Corporation.
   8. Or approved custom box manufacturer.

2.7 CABINETS

A. Comply with UL 50, "Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations."

B. General: NEMA type and size as required by area, application, or as shown. Cabinet shall consist of a box and a front consisting of a one piece frame and hinged door. Hinged side shall be dependent upon physical application. Arrange door to close against a rabbet placed around the inside edge of the frame, with a uniformly close fit between door and frame. Provide concealed fasteners, not over 24 inches apart, to hold fronts to cabinet boxes and provide for adjustment. Provide flush or concealed door hinges not over 24 inches apart and not over 6 inches from top and bottom of door. Louvers for cabinet ventilation shall be provided as required by application. For flush cabinets, make the front approximately 3/4 inch larger than the box all around. For surface mounted cabinets make front same height and width as box.

C. Doors: Double doors for cabinets wider than 24 inches. Cabinets wider than 48 inches may have sliding or removable doors.

D. Locks: Combination spring catch and key lock, with all locks for cabinets of the same system keyed alike. Locks may be omitted on signal, power and lighting cabinets located within wire closets and mechanical-electrical rooms. Locks shall be of a type to permit doors to latch closed without locking. Latch shall be padlocking type for exterior applications.

E. Galvanized Sheet Steel: Minimum 14 gauge, solder or braze all seams, roll edges at openings and minimum 12 gauge doors to match panelboard enclosures.

F. Sheet Aluminum: Type 5052 H-32 sheet aluminum, minimum 0.125 inch thickness, welded seams, gasketed weathertight door, stainless steel hinge, and stainless steel padlockable latching mechanism.
G. Sheet Stainless Steel: Type 316L sheet stainless steel, minimum 16 gauge thickness for enclosures 20 inch wide and less, otherwise 14 ga. welded seams, gasketed weathertight door, stainless steel hinge, and stainless steel latches and padlockable hardware.

H. Acceptable Manufacturers:
   1. Square-D.
   2. Chicago Switchboard.
   3. Cutler Hammer/Westinghouse.
   7. Lee Products.
   8. Crenlo, Inc.
  10. Electromate Corporation.
  11. Siemens.
  12. Hennessy Products, Inc.
  13. Wiegman, a Division of Hubbell, Inc.

2.8 ACCESSORIES

A. Ground Provision: Provisions for each box and cabinet, to facilitate bonding to the building ground system.

B. Preformed Acoustical Seal for Outlet Boxes: Manufacturer's standard molded neoprene, durometer A-40 complying with ASTM D2000, formed and cut to fit the electrical device and outlet box. Product effectively increases the STC of outlet boxes by 6 dB as demonstrated by testing representative assemblies according to ASTM E 90 (Small Scale Test).

1. Products: Subject to compliance with requirements, provide the following:
   a. STC Architectural Products; Box Seal, info@stcsoundseal.com.
   b. Or other approved manufacturer

2. Configurations: To match installed device.


4. Applications: Provide for each outlet in sound-rated partitions where specifically indicated on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Install items where indicated and where required to suit code requirements and installation conditions.

B. Maintain the environmental rating of the enclosures. Install in the openings only listed or recognized conduit hubs or conduit and raceway fittings providing the same rating and integrity as the enclosure, in compliance with the installation instructions of the device.

1. Cap unused knockout holes where blanks have been removed and plug unused conduit hubs.
3.2 APPLICATIONS

A. Provide electrical identification as indicated in Division 26 Section "Electrical Identification."

B. Cabinets: NEMA Type 1, installed flush, unless noted or indicated otherwise.

C. Boxes and Fittings: Install concealed, unless noted otherwise, with associated covers and fittings of materials and NEMA types suitable for each location and in conformance with the following requirements.
   1. Interior Dry Locations: Sheet steel, NEMA Type 1.
   2. Interior Wet or Damp Locations, or Exposed to Weather: Cast metal, NEMA Type 3R.
   3. Outdoor and Indoor Wet Locations: NEMA Type 4x enclosures with type 316L stainless steel. Hot dip galvanized cast iron outlet boxes.
   4. Hazardous (Classified) Locations: NEMA Type listed and labeled for the location and class of hazard indicated.

D. Exterior walls shall not be considered dry locations for concealed exterior devices. Sheet steel boxes shall not be used.

E. Galvanized steel boxes may be installed in:
   1. Concealed interior locations above ceilings and in hollow studded partitions.
   2. Exposed interior location above 7 feet.
   3. Direct contact with concrete except slab on grade.
   4. Stud walls of kitchens and laundries.

F. Cast boxes shall be installed in:
   1. Exterior locations.
   2. Hazardous locations.
   3. Within seven feet area around boilers, incinerators and other heat producing equipment.
   4. Direct contact with earth.
   5. Direct contact with concrete in slab on grade.
   6. Wet locations.

G. Sectional Field Gangable Boxes:
   1. Shall not be used in any application, unless approved by engineer.

H. Pull and Junction Boxes: Install pull and junction boxes of materials and NEMA types suitable for each location except as otherwise indicated.
3.3 INSTALLATION - BOXES

A. Provide box sizes as required by the National Electrical Code with oversize boxes as shown on Drawings. Obtain special backboxes with associated equipment when available.

B. Provide where required for outlet facility and rough-in requirements. Securely support from building construction with listed and approved rods, hangers, brackets, supports, etc., independent of raceways. Provide backing extension for all steel device boxes in stud walls or support box on two opposite sides such that cover plate and drywall is not stressed to hold box in position.

C. Give priority in available space to large steam mains, steam lines that pitch, waste lines, drain lines, large air duct, and all structural steel, unless shown otherwise.
   1. Minimum Spacing: 3 inches between boxes and cold water or waste piping and 6 inches between boxes and parallel steam pipes, condensate pipes, hot water pipes and air ducts.
   2. Do not support from ceiling supporting system, or mechanical systems.
   3. Do not penetrate or anchor into mechanical ductwork.

D. Install concealed, flush to finished wall, floor or ceiling construction materials except where otherwise shown or specified as surface mounted. To maximize available future wall space, do not assume surface mounted boxes or associated raceways in equipment or electrical rooms.

E. Maintain accessibility to all boxes. For the purposes of this specification section, Z-spline ceilings shall not be considered accessible.

F. Provide and install concealed boxes, so no part is visible, and is completely covered by wall plate, luminaire, etc.

G. Do not cut insulation in walls to install boxes.

H. Do not use 2-sided, through wall boxes.

I. Do not install concealed, flush boxes back to back for both fire and sound rating issues. Drawings are considered diagrammatic. Those installations not approved shall be corrected at no cost to the Owner.

J. Install boxes so that cover or plate will not span different building finishes.

K. Where two or more devices are shown or otherwise specified to be installed at the same location and at the same height, install those devices in a common multi-gang barriered box as appropriate for the device types.
   1. Maintain box and raceway separations per NEC. Pullbox barriers will not be acceptable except for special cases brought to the Engineer's attention prior to installation.

L. Where two or more devices are shown or otherwise specified to be installed at the same location but at different height elevations, rough the boxes vertically on a common center line.

M. Install in center of glazed tile, brick, block or other masonry wall material.

N. In tile, brick or block install a adjustable mud rings to ensure device and plate are flush with final finish.

O. Close off all unused openings with proper fittings.
P. Install outlet boxes for electric water coolers concealed inside cooler cabinet. Install outlet boxes using rough-in template furnished with cooler.

Q. Combination devices (i.e. switch and receptacle) shall be installed in minimum 2 gang box under common wall plate.

R. Provide box and cabinet barriers to segregate voltages 300 volts and greater and to segregate normal and emergency distribution system branches.

S. Set floor boxes and service fittings level at height to match trim with flooring type.

T. Provide a minimum 2 gang box for all exterior equipment connection boxes.

3.4 INSTALLATION - PULL AND JUNCTION BOXES

A. All boxes shall be concealed and accessible after completion of building.

B. Installation in finished spaces requiring access panels is prohibited except where specifically shown or directed.

3.5 IDENTIFICATION

A. Per Division 26 Section "Electrical Identification."

3.6 BOX COVERS

A. Provide appropriate covers for all boxes dependent upon size, type, and application.

3.7 INSTALLATION - CABINETS

A. Support securely independent from building construction and align with adjacent equipment. Top shall be 6 foot - 2 inches to top of trim.

3.8 GROUNDING AND BONDING

A. Electrically bond metallic cabinets, boxes, enclosures and their associated raceways to the building grounding and system. Where wiring to box or cabinet includes a grounding and bonding conductor, provide a terminal in the interior of the cabinet, box or enclosure, and connect conductor.

3.9 ACOUSTICAL SEAL FOR OUTLET BOXES

A. Place seal over exposed outlet box flush with wall surface with device protruding through preformed or precut opening in seal. Secure in place with outlet cover plate.

3.10 CLEANING AND FINISH REPAIR

A. Upon completion of installation, inspect components. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, abrasions, and weld marks.

B. Galvanized Finish: Repair damage using a zinc-rich paint recommended by the tray manufacturer.

C. Painted Finish: Repair damage using matching corrosion inhibiting touch-up coating.

END OF SECTION 260535
PART 1 - GENERAL

1.1 SUMMARY

A. This section includes underground electrical raceway work including the following:
   1. Underground raceway and duct banks.

1.2 DEFINITIONS

A. Duct: The general term for electrical conduit and other raceway, either metallic or nonmetallic, specified for use underground or embedded in earth or concrete.

B. Duct Bank: A group of two or more ducts in a continuous run between two points.

C. Handhole: A below-the-surface enclosure with flush to grade access into which people reach, but do not enter, provided in conjunction with ducts/duct banks for the purpose of installing, operating, or maintaining equipment or wiring.

D. Manhole: A below-the-surface enclosure or chamber, with flush to grade access, large enough for a person to enter, provided in conjunction with ducts, and affording facilities for installing, operating, and maintaining equipment or wiring.

E. Concrete Pullbox: A below-the-surface enclosure, with flush to grade access, into which people reach, but do not enter, provided in conjunction with underground raceways, for the purpose of installing wiring.

1.3 SCHEDULING

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Construction Manager and Owner no fewer than fourteen (14) days in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without Construction Manager’s or Owner’s written permission.

1.4 COORDINATION

A. Coordinate layout and installation of handholes with final arrangement of ducts as influenced by actual final location of other utilities in the field.

B. Coordinate elevations of duct and raceway entrances into manholes and handholes with final profiles of conduits as determined by coordination with other utilities and underground obstructions. Revise locations and elevations from those indicated as required to suit field conditions and assure duct runs drain to manholes and handholes and as approved by the Architect.

1.5 SUBMITTALS

A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."
1.6 ACTION SUBMITTALS
   A. Product Data:
      1. Duct bank materials, including separators and miscellaneous components.
      2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
      3. Handholes, pull boxes and their accessories.
      4. Warning tape.

1.7 INFORMATIONAL SUBMITTALS
   A. Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures. Submit after utility company review.
      1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
   B. Field quality control test reports.

1.8 CLOSEOUT SUBMITTALS
   A. Record Documents:
      1. Provide color copies (8-1/2" x 11") and electronic format; JPEG or approved other for all underground installation prior to backfill with raceway and manhole identification.

1.9 DELIVERY, STORAGE, AND HANDLING
   A. Deliver ducts to site with ends capped. Store ducts with supports to prevent bending, warping, and deforming.
   B. Store precast concrete units at site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.
   C. Lift and support precast concrete units only at designated lifting or supporting points.

1.10 FIELD CONDITIONS
   A. Subsurface conditions were investigated during the design of the project. Reports of these investigations are available for informational purposes only. Data in the reports are not intended as representations or warranties of accuracy regarding continuity of conditions (between soil borings or test kits). The Owner will assume no responsibility for interpretations or conclusions drawn from this material.
   B. Existing Utilities: Information on underground utilities and possible obstructions in the path of construction under this section was obtained through investigations during the design of the project. Reports of these investigations are available for informational purposes only. Data in the reports are not intended as representations or warranties of accuracy regarding conditions and locations. The Owner will assume no responsibility of interpretations or conclusions drawn from this information.
PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the listed manufacturers for the project.

2.2 REGULATORY REQUIREMENTS
   A. Comply with ANSI C2.
   B. Comply with NFPA 70.

2.3 DUCTS AND FITTINGS
   A. General: Ducts and duct fittings and accessories for which listing has been obtained by one or more manufacturers shall be UL listed and labeled.

2.4 TYPE
   A. Underground duct bank raceways may utilize the following types of conduits, fittings, outlets, and seals in compliance with Division 26 Section "Raceways":
      1. Rigid galvanized steel.
      2. Intermediate metallic conduit.
      3. Coated rigid galvanized steel.
      4. PVC Schedule 80.
      5. PVC Schedule 40.
   B. Special Requirements:
      1. Fittings shall be suitable for a watertight installation. The following fittings are among those required:
         a. Sweep elbows 4 foot minimum radius. Radius bends, long sweep type. Bend segments and/or 5 degree angle coupling.
         b. Terminating vertical elbows at buildings and concrete pads shall be coated, rigid galvanized steel. Terminating bushings shall be insulated grounding type. Provide corrosion protection (red lead or equal) for all cut and threaded ends.
         c. Provide coated, rigid galvanized steel conduit for the first 10 foot section when leaving a building or sections passing through floor slabs.
         d. Provide end bells for horizontal raceways terminating in a manhole or building.
      2. Quantities and sizes - as shown on Drawings.
      3. Watertight Seals:
         a. Conduits penetrating outer building walls.
            1) For conduits penetrating outer building walls, refer to "conduit seals" specified in Division 26 Section "Raceways."
         b. Underground concrete encased raceways penetrating outer building walls.
            1) For underground concrete encased raceways penetrating outer building walls, utilize duct seal.
            2) Approved Duct Seal Manufacturers:
4. Conduit Spacers and Levelers:
   a. Vertical PVC interlocking style providing 2 inch minimum vertical and horizontal separation with minimum 2 inch base plate and holes for reinforcing bars.
   b. Approved Manufacturers:
      1) Cantex
      2) Carlon.
      3) Condux.
      4) Underground Devices, Inc.

5. Underground Raceway Marking Tape:
   a. Provide as specified in Division 26 Section "Electrical Identification."

6. Drag Line (Fishwire):
   a. Minimum 1/8 inch wide polypropylene monofilament utility rope.
   b. Approved Manufacturers/Series:
      1) American Synthetic Ropes – Flotorope.
      2) Greenlee Tool Co. - 2 Ply Rope 431.
      3) Ideal Industries - Pro-Pull Rope.

2.5 CAST-IN-PLACE CONCRETE
   A. Conform to Division 03 Section "Concrete Work" for concrete and reinforcing.
   B. Aggregate For Duct Encasement: 3/8 inch maximum size.
   C. Strength: 3000 psi minimum 28 day compressive strength.

2.6 MANHOLES AND HANDBOLES
   A. Vaults:
      1. Sectional precast reinforced concrete construction designed for minimum dimensions shown on Drawings. Complete with 8 inch anchored pulling-in irons, hold down bolts, cast metal sump pocket 12 inch deep with grate, one access opening in top, wall inserts for 3 cable rack supports per side wall and one per end wall, and 1 inch opening for ground rod in bottom. A cable pulling-in iron shall be installed in each wall.
      2. Factory-fabricated of reinforced concrete and in conformance with ANSI C 2, "National Electrical Safety Code" and applicable requirements of ASTM C 858. Manhole structure shall be designed in accordance with requirements of the American Association of State Highway and Transportation Officials (AASHTO) publication "Standard Specifications for Highway Bridges." AASHTO H20 highway loading shall apply with 30 percent loading added for impact.
      3. Precast Units: Consisting of interlocking, mating sections, complete with accessory items, hardware, and features as indicated including cast end bell or duct terminating fitting wall panels for conduit entrance and sleeve for ground rod.
4. Concrete Knockout Panels: 1-1/2 to 2 inches (38 to 50 mm) thick, for future conduit entrance and sleeve for ground rod.

5. Joint sealant for joints between precast sections shall be continuous extrusion of asphaltic butyl material compounded for the adhesion, cohesion, flexibility, and durability properties required for a permanent seal against the maximum hydrostatic pressures theoretically attainable at the installation location with the ground water level at grade.

6. Shall generally be 6 ft. W x 6 ft. D x 8 ft. H, unless otherwise as shown on Drawings.

7. Wall minimum 6 inch thick reinforced concrete (30 inch x 30 inch manholes minimum 4-1/2 inch thick reinforced walls).

8. Top slab minimum 6 inch thick reinforced concrete (top slab not required for 30 inch x 30 inch manholes).

9. Bottom slab minimum 6 inch thick reinforced concrete (30 inch x 30 inch manholes minimum 4 inch thick reinforced bottom slab).

10. Approved Manufacturers:
    a. Lakelands Quickset.
    b. Fort Miller.
    c. Kistner Concrete.
    d. Rotondo/Penn-Cast, Inc.
    e. Smith-Midland Corp.
    f. Warsaw Concrete Co.

B. Covers and Frames:


2. Clear opening of not less than 27 inches in diameter.

3. Heavy duty cast iron frame minimum height 6-1/2 inches with not less than 6 integral gussets and 1 inch thick flange. Flange may be round or square to fit manhole requirements and have a bearing on masonry minimum 600 square inches.

4. Round cover, minimum 1-1/4 inch thick cast iron, reinforced on the underside by integral cast ribs and with an unperforated, checkered surface.

5. 6 inch letter "P" cast in cover for power manholes. 6 inch letter "S" cast in cover for communication/special systems manholes.

6. Approved Manufacturers:
    a. Campbell Foundry Co.
    b. Flockhart Foundry Co.
    c. Neenah Foundry Co.
    d. Woodward Foundaries.

C. Manhole Hardware and Accessories:

1. Sump Frame and Grate: Comply with FS-RR-F-621, Type VII for frame, Type I for cover.


   a. Stanchions: Nominal 36 inches (900 mm) high by 4 inches (100 mm) wide, with minimum of 9 holes for arm attachment.
b. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 20 inches (508 mm) with 250-lb (114-kg) minimum capacity. Top of arm shall be nominally 4 inches (100 mm) wide, and arm shall have slots along full length for cable ties.

3. Manhole Ladder: Round rungs, seven foot long or as needed with hook ends.
   a. Approved Manufacturer/Series:
      1) Condux 83820 Series.
      2) Or approved equal.

   a. Approved Manufacturers/Series:
      1) Condux 83813 Series.
      2) Or approved equal.

5. Manhole Cover Lifting Hook: Condux 80230-00 or equal. Supply two (2) only.

6. Pulling Eyes in Walls: Eyebolt with rebar fastening insert. 2 inch diameter eye, 1 inch by 4 inch long bolt. Working load embedded in 6 inch, 4000 psi concrete: 13,000 pounds minimum tension.

7. Bolting Inserts for Cable Stanchions: Flared, threaded inserts of noncorrosive, chemical resistant, nonconductive thermoplastic material. 1/2 inch internal diameter by 2-3/4 inches deep, flared to 1-1/4 inch minimum at base. Tested ultimate pull-out strength: 12,000 pounds, minimum.

8. Expansion Anchors for Installation after Concrete is Cast: Zinc-plated carbon steel wedge type with stainless steel expander clip 1/2 inch bolt size, 5,300 pound rated pull-out strength, and 6,800 pound rated shear strength, minimum.

D. Manhole Mortar:
   1. One part of Portland cement to 2 parts sand mixed with water for proper consistency.
   2. Conform to ASTM C 270, Type M, except for quantities less than 2.0 cu. ft., where packaged mix complying with ASTM C 387, Type M may be used.

E. Manhole Brick:
   1. Concrete Brick Type I, Grade N, conforming to ASTM C55.

F. Waterproofing:
   1. Elastic bituminous plastic cement (coal-tar base) conforming to Fed. Spec. SS-C-153 Type II.

2.7 NON-METALLIC POLYMER CONCRETE PULLBOXES
A. Shall be listed electrical enclosures, having 4 sides, solid bottom, and removable top. Shall be designed, fabricated, and tested to ANSI/SCTE 77-2002 – Specification for Underground Enclosure Integrity.
B. Material: Enclosures shall be non-metallic, fabricated from a polymer concrete mix of selectively-graded aggregates in combination with a polymer resin, reinforced with fiberglass. Enclosures shall:
   1. Be impact resistant — tested per ASTM D-2444.
   2. Provide low water absorption — less than 1 percent per ASTM D-570.
   3. Be corrosion resistant — resistant to alkalines, acids, weathering and other forms of deterioration.
   4. Be nonflammable — will not support combustion.
   5. Be nonconductive — no grounding required for the box or cover.

C. Performance Rating: Enclosures, covers, and their accessories, shall be rated Tier 15.

D. Color: Enclosure and cover shall be Grey.

E. Size: shall be as noted on the drawings.
   1. Enclosures shall be sized in accordance with NEC Article 314.28(A) for conductors operating at 600 volts or below, and in accordance with NEC Article 314.71 for conductors operating at over 600 volts.

F. Depth shall be as noted on the drawings.

G. Wiring Entries: Raceways and cable assemblies entering a handhole enclosure underground shall be required to be mechanically connected to the enclosure.
   1. The enclosed conductors, splices, and terminations shall be listed as suitable for wet locations.

H. Covers: Shall be inset flush to pullbox top, bolt down type, with not less than 4 stainless steel fasteners, and provided with weathertight gasketing or grommet to prevent the ingress of weather elements.
   1. Shall have a permanent identifying mark or logo that prominently identifies the function or application of the enclosure, such as "ELECTRIC."
   2. Shall be factory provided with the design Tier level rating embossed on the cover surface.
   3. Cover design load rating cannot exceed the design load rating of the enclosure.

I. Referenced Products: Quazite – PG Style, or approved equivalent.

PART 3 - EXECUTION

3.1 DEFINITION
A. For Part 3 - EXECUTION, the words manhole and handhole are synonymous.

3.2 PREPARATION
A. Refer to Drawings for special construction and dimensional requirements.
B. Provide all trenching, excavating, backfilling, and concrete required for underground duct bank raceway installations in accordance with Division 02 and Division 03. The exact location of each duct bank raceway shall be determined after careful consideration has been given to the location of other utilities, grading, and paving.
C. Lay out the proposed course and obtain location approvals prior to installations.

D. Obtain installation approval prior to concrete pour.

3.3 CORROSION PREVENTION

A. Protect all metallic materials against corrosion. Exposed metallic parts of outdoor apparatus shall be given a rust-inhibiting treatment and standard finish by the manufacturer. Aluminum shall not be used in contact with the earth, and where connected to dissimilar metal shall be protected by approved fittings and treatment. All parts such as boxes, bodies, fittings, guards, and miscellaneous parts made of ferrous metals but not of corrosion-resistant steel, shall be zinc-coated in accordance with ASTM A123 or A153, except where other equivalent protective treatment is specifically approved. Steel conduits installed underground or under slabs on grade shall be coated with an approved asphaltic paint, plastic coating or shall be wrapped with a single layer of a pressure-sensitive plastic tape, half-lapped. Where pressure-sensitive plastic tape is used, the conduit shall be coated with a primer recommended by the tape manufacturer before applying the tape.

3.4 INSTALLATION UNDERGROUND DUCT BANK RACEWAY

A. General:

1. Raceway Handling:
   a. Keep raceways clean of concrete, dirt, or foreign substances during construction. Raceways shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Raceways shall be thoroughly cleaned before being laid. Plastic raceways shall be stored on a flat surface and protected from the direct rays of the sun.

2. Raceway Envelope:
   a. Raceways shall be generally direct buried.
   b. Raceways shall be reinforced and concrete encased for the following conditions:
      1) Service entrances.
      2) Generator/Emergency Power Feeders 50 amps and larger.
      3) Normal Power Feeders 100 amps and larger.
      4) Medium Voltage Feeders
      5) Any raceway less than 30 inches below the surface of a roadway.

B. Depth:

1. Existing Grade to Remain:
   a. Install raceways more than 30 inches below the existing finished grade unless otherwise indicated or directed.

2. Existing Grade Lower than Finished Grade:
   a. Install raceways more than 30 inches below the existing grade unless otherwise indicated or directed.

3. Existing Grade Higher than Finished Grade:
   a. Install raceways more than 30 inches below the finished grade unless otherwise indicated or directed.
4. Concrete Encased Raceways:
   a. Install concrete encased raceways more than 30 inches below finished surface unless otherwise indicated or directed.

5. Crossing Obstructions:
   a. Install rigid galvanized steel conduit where top of conduit system is less than 18 inches below finished grade when crossing obstructions (tunnels, steam lines, etc.).

C. Pitch:
   1. Pitch raceways to drain into manholes and away from buildings and concrete pads sloping not less than 12 inches per 100 feet. Where no manhole exists in run, pitch toward building with closest and safest drain access. On runs between manholes where it is impossible to maintain the grade all one way, grade from center so that conduits pitch both directions toward manholes.

D. Footings:
   1. Direct Buried Raceways:
      a. Tamp and level grade, for pitch desired, the bottom of raceway trenches.
      b. Excavate an additional 3 inches where rock, soft spots, and/or sharp edged materials are encountered, then fill and tamp level with the original bottom with sand or earth free from particles to approximate densities of surrounding firm soil to minimize conduit stress.
   2. Concrete Encased Raceways:
      a. Provide footing bed identical to direct buried raceways.

E. Raceway Installation:
   1. General:
      a. Maintain and ensure full, even support of raceways throughout their entire length.
      b. Raceway joints may be placed side by side horizontally but shall be staggered a minimum of 6 inches vertically.
      c. Make raceway joints watertight.
      d. Provide perimeter seals where raceways and encasements penetrate walls.
   2. Direct Buried Raceways:
      a. Hold lowest horizontal raceways in alignment with earth.
      b. Use a wooden frame or equivalent form to hold ducts in high-tiered banks in alignment prior to backfilling. Thoroughly tamp in 4 to 6 inch layers above raceways with selected earth.
      c. Side fill around raceway layers and hand tamp prior to earth layer tamping. Do not tamp directly on top of raceways.
      d. Remove frame as side fill is placed under raceway layers. If blocks or spacers are used for alignment, remove, fill, and tamp vacant spaces as ducts are laid.
   3. Concrete Encased Raceways:
a. Reinforce encasement with No. 4 bars 12 inches on center parallel with raceway run and No. 4 bar loops 18 inches on center perpendicular to raceway run within perimeter of encasement by 3 inches.

1) Exception: Parking lot and roadway lighting branch circuit raceways (if required to be concrete encased) do not need reinforcement unless required by other sections.

b. Encase raceway with a rectangular or monolithic concrete cross-section providing formwork as necessary. Where connection is made to a previously poured encasement, the new encasement shall be doweled square to the existing encasement.

c. Provide a minimum of 6 inches of concrete cover around raceway bank perimeter and 2 inches between adjacent raceways.

1) Exception: For parking lot and roadway lighting branch circuit raceways, concrete cover is not required unless required by the NEC, which in that instance provide minimum 3 inch cover.

d. Avoid pouring a heavy mass of concrete directly on raceway. If unavoidable, protect with a plank. Direct the flow of concrete down the sides of the bank assembly to the bottom, compelling concrete to flow to the center of the bank and to rise up in the middle, thus filling all spaces uniformly. Ensure the absence of voids by working a long flat slicing bar or spatula liberally and carefully up and down between the vertical rows of raceways.

F. Identification

1. Refer to Division 26 Section "Electrical Identification" for installation requirements.

G. Backfilling:

1. Provide a brightly colored corrosion resistant plastic warning tape about 12 inches below top of trench in backfill. The tape shall be suitably inscribed at not more than 10 feet on centers to permit easy identification and location of the raceway run. Refer to Division 26 Section "Electrical Identification."

2. Backfill shall be free from scrap material. Place backfill over raceways in tamped layers of 6 inches maximum each.

3. Patch pavement, sidewalks, curbs, and gutters where existing surfaces are removed for construction. (Match existing construction).

H. Cleaning Raceways:

1. General:

a. Prevent foreign matter from entering all raceways during installation.

2. New Raceways:

a. After installation, clean raceways with tools designed for the purpose.
3. Existing Raceways:
   a. Clean raceways with tools designed for the purpose. The condition of the raceways after cleaning shall be determined, preferably with a mandrel 1/2 inch less in diameter than the raceway, with the sheath painted with black lacquer. Pull mandrel through raceway. Raceway is acceptable where there are no roller marks or scratches on the mandrel. Other methods may be used if approved.

4. Report and demonstrate to the Owner's representative any defect found in the raceway systems that cannot be eliminated. Be responsible for any damage to cables resulting from imperfections in the raceways.

I. Capping Raceways:
   1. Spare Raceways:
      a. Seal the ends of new and/or existing spare conduits at concrete pad, building wall, and manhole penetrations. Seal with wood or plastic plugs or a contrasting color cement/sand mixture with wick for drainage.
      b. Demonstrate to the Owner's representative that raceways installed for future use are clear of obstructions (draw mandrel 1/2 inch less than raceway). Install a drag line in each raceway penetrating through seal and pigtail minimum 2 feet. Provide wick for drainage.

   2. Occupied Raceways:
      a. Seal the ends of raceways to be used for this contract until cables are to be installed. After cable installation, seal raceways at slabs, building entrances, and first manhole outside building. Seal with seal duct leaving wick for drainage.

   3. Spare Parking Lot and Roadway Raceways:
      a. Seal and cap raceway utilizing approved raceway cap fitting.

3.5 INSTALLATION – MANHOLES AND HANDHOLES

A. Make excavation per manhole manufacturer's recommendations. Provide compacted pea gravel bedding not less than 6 inches deep. Set vault true and level at proper depth for underground duct bank raceway entrance.

B. Where existing grades that are higher than finished grades are encountered, a sufficient number of courses of brick shall be installed between the top of manhole and manhole frame to elevate temporarily the manhole cover to existing grade level.

C. Coat bottom, exterior walls, and top of manhole with two coats of waterproofing sealer to make watertight. Provide additional sealant to fully seal joint between manhole walls, duct banks, and joints. Paint frame and cover with two coats of waterproofing paint after inspection and approval of the Architect.

D. Backfill after Architect's representative's approval. Use only selected and screened backfill within 12 inches of duct bank and manhole wall. Obtain 95 percent compaction of backfill.

E. Provide suitable masonry "throat" between top of manhole and cover frame. In paved areas, the top of manhole covers shall be flush with the finished surface of the paving. In unpaved areas, the top of manhole covers shall be approximately 1/2 inch above the finished grade. Provide at least 6 inches of masonry around frame at grade.
F. Install cable racks and other vault fittings. Route cables on cable supports around periphery of manholes using longest path to allow for slack as well as cable bending relaxation.

G. Wiring Raceway Separations within Manholes:
   1. Provide raceway separation, per NEC, between wiring and as follows:
      a. 600 Volts and Below: Above 600 volts.
      b. Below 50 Volts: 50 volts and above.
      d. Switchgear relaying circuits and other wiring.
      e. Automatic transfer switch control circuits and other wiring.
      f. Fire Alarm and Building Automation System circuits and other wiring.

3.6 INSTALLATION – GROUNDING AND BONDING

A. General:
   1. Provide grounding materials per Division 26 Section "Grounding and Bonding."
   2. Bond all equipment frames, cable shield, cable racks, ground bus, conduit, and ground rods to the ground wire. Use fusion welds or approved irreversible connectors.
   3. Ground rods shall be protected with a double wrapping of pressure-sensitive plastic tape for a distance of 2 inches above and 6 inches below concrete penetrations or shall be protected from corrosion by other suitable means as approved by Engineer. Ground wires (minimum No. 6 AWG) shall be neatly and firmly attached to manhole or handhole walls and the amount of exposed bare wire shall be held to a minimum.
   4. Install separate equipment ground conductor for non-metallic raceways per Division 26 Sections "Raceways" and "Grounding and Bonding."

B. Medium Voltage Cable Grounding:
   1. Ground rods installed in electrical distribution system manholes shall be properly connected to medium voltage cable shielding, metallic sheath, and armor at each cable joint or splice by means of No. 4 AWG or equivalent braided tinned copper wire when so installed. Connections to metallic cable sheaths shall be by means of tinned terminals soldered to ground wires and to cable sheaths. Care shall be taken in soldering not to damage metallic cable sheaths or shields.

3.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:
   1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
   2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
   3. Test manhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding and Bonding."
B. Water Tightness: Make internal inspection of manholes/handholes three months after completion of construction for indications of water ingress. Where leakage is noted, remove any water found and seal leakage sources. Reinspect after two months and reseal any remaining leakage sources. Repeat process until leakage is corrected.

C. Correct deficiencies and retest as specified above to demonstrate compliance.

END OF SECTION 260543
SECTION 260544 – SLEEVES AND SLEEVE SEALS FOR RACEWAYS AND CABLELING

PART 1 - GENERAL

1.1 SUMMARY
   A. Section Includes:
      1. Sleeve coordination and installation.
      2. Sleeves for raceways and cables.
      3. Watertight sleeve seals.

1.2 DEFINITIONS
   A. EPDM: Ethylene-propylene-diene-monomer rubber.
   B. NBR: Acrylonitrile-butadiene rubber.

1.3 COORDINATION
   A. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
   B. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
   C. Cut and patch for sleeve installations. Coordinate with work of other trades.
   D. Coordinate sleeves with cable installer(s).
   E. Coordinate with cable installer to ensure cables are rigidly supported on both sides of the floor or wall assembly.

1.4 SUBMITTALS
   A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.5 INFORMATIONAL SUBMITTALS
   A. Coordination drawing depicting sleeve locations.

PART 2 - PRODUCTS

2.1 SLEEVES FOR CABLES
   A. Steel Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
   B. Cast-Iron Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
   C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch (1.3 or 3.5-mm) thickness as indicated and of length to suit application.
D. Re-penetrable cable management sleeve. Provide penetration firestopping system with ratings as described in Division 07 Section “Penetration Firestopping” and the ability to add or remove cables without the need for replacing fill materials.

1. Manufacturers: Subject to compliance with requirements, provide the following product:
   a. CP 653 Speed Sleeve by Hilti, Inc, for multiple cable bundle penetrations.
   b. Firestop Cable Disc® by Hilti, Inc., for single cable penetrations, selected for the type of surrounding barrier material.

2.2 WATERTIGHT SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
3. Pressure Plates: Plastic. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.


C. Design Mix: 5000-psi (34.5MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Install sleeves, conduits, and cables with required clearance spaces allowing proper installation of wall and sealing materials. At no time exceed the outside diameter of the sleeve conduit or cables penetrating barriers by more than 2 inch or less than 1/4 inch for all penetrations of barriers. If access openings are required in raceway, install 24 inch minimum lengths of runs between access openings and point of entry into barriers. Perform all patching of barriers as required. Patch with materials compatible with barrier construction and fire resistant rating equal to, or greater than, the barrier rating.

B. Coordinate firestopping at all raceways and cables passing through floor structures and interior walls noted as fire resistant rated barriers, and interior walls noted as smoke barriers.
C. Coordinate rating of smoke and fire barriers where electrical boxes, cabinet, or equipment is installed within using firestopping pads or foam.

D. All sleeves shall be labeled as to which voltage cable is to be used within the sleeve. Intermixing of voltage type shall not be permitted.
   1. Fire Alarm cables shall be in separate dedicated sleeve from all other cables.
   2. Each antenna signal cable (DAS, Way Finding, Clock, etc.) shall be provided with a separated dedicated sleeve.
   3. Data (nurse call, coax, Vocera, etc.) cables may share the same sleeve.
   4. Shielded and non-shielded cables shall not share a common sleeve.

3.2 SLEEVES INSTALLATION FOR CABLE PENETRATIONS
A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. Aggregate cross-sectional area of cable(s) shall be maximum 45 percent of the associated opening or sleeve.

C. Install bushed metallic raceway where passing through fire rated vertical barriers.

D. Install 4” re-penetrable cable management sleeves ("Speed Sleeve") above corridor smoke barrier doors. Install a minimum of one 4” sleeve at all smoke barrier door locations.

E. Install only bushed metallic raceway where passing through floors or horizontal fire barriers except where cable is totally enclosed in a fire resistant rated shaft.

F. Concrete Slabs and Walls: Install cast iron sleeves for penetrations unless core drilled holes or formed openings are used in concrete slabs and walls. Install watertight sleeves during erection of slabs and walls.

G. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

H. Rectangular Sleeve Minimum Metal Thickness:
   1. For sleeve rectangle perimeter less than 50 inches (1270 mm) and no side greater than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
   2. For sleeve rectangle perimeter equal to, or greater than, 50 inches (1270 mm) and 1 or more sides equal to, or greater than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

I. Cut sleeves to length for mounting flush with both wall surfaces 2 inches per side for bushings.

J. Provide minimum clearance space of 2 inches from opening to all adjacent raceways, ducts, pipes, sleeves, etc., when penetrating barriers.

K. Provide after-set sleeves at all concrete floor penetrations to extend up above floor 2 inches when a penetration is required of an existing slab condition. Core drill hole 1/2 inch diameter less than sleeve size. Core drill larger hole partway thru floor slab to allow sleeve to sit in place. Provide tight pack dry grout fill in core cut all round sleeve and provide gun applied sealant all around with sloped finish. Pack fire safing insulation all around raceway and provide 3/4 inch deep gun applied sealant all around at top of penetration.

L. Size pipe sleeves to provide 1/4 inch (6.4 mm) annular clear space between cables and between sleeve and cable unless sleeve seal is to be installed.

M. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
N. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth and location of joint according to Division 07 Section "Joint Sealants."

3.3 WATERTIGHT SLEEVE SEAL INSTALLATION
   A. Install to seal exterior wall penetrations.
   B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING
   A. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 260544
SECTION 260548 - VIBRATION CONTROLS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following:
   1. Inertia isolation pads.
   2. Spring isolators.
B. Provide inertia isolation pads under equipment bases for:
   1. Transformers equal to or less than 300 KVA.
C. Provide spring isolators for:
   1. Floor mounted transformers larger than 300 KVA.
   2. Suspended transformers.
D. Related Sections include the following:
   1. Division 26 Section "Hangers and Supports" for commonly used electrical supports and installation requirements.

1.2 DEFINITIONS

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: For the following:
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of component used.

1.5 QUALITY ASSURANCE
A. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS
A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ace Mountings Co., Inc.
   2. Amber/Booth Company, Inc.
4. Isolation Technology, Inc.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.

C. Inertia Isolation Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
   1. Resilient Material: Oil- and water-resistant neoprene.
   2. Type MN having a minimum static deflection of 1/4 inch.

D. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
   1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
   6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine areas and equipment to receive vibration isolation for compliance with requirements for installation tolerances and other conditions affecting performance.
   B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
   C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS
   A. Vibration Isolators:
      1. All floor supported transformers in excess of 300 KVA located within the building shall be mounted on isolation units utilizing type MS springs, appropriately secured to the transformer housing. Spring units shall be selected for a minimum static deflection of 1.5 inch.
      2. All floor supported transformers equal to or less than 300 KVA located within the building shall be mounted on MN neoprene mounts selected to deflect a minimum of 0.25 inch.
      3. Suspended transformers of less than 45 KVA shall be supported on an appropriate steel frame from Type HS hangers, selected for a minimum static deflection of 0.75 inch.
3.3 FIELD QUALITY CONTROL
   A. Inspections and Tests:
      1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing, ANSI/NETA ATS, "System Functional Tests", and "Thermographic Survey" requirements, and the following additional requirements:
         a. Prepare test and inspection reports.

3.4 ADJUSTING
   A. Adjust isolators after isolated equipment is at operating weight.
   B. Adjust active height of spring isolators.
   C. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 260548
VIBRATION CONTROLS

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SECTION 260553 – ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes:
   1. Identification for raceway, busway, and cable.
   2. Identification for conductors and communication and control cable.
   4. Warning labels and signs.
   5. Instruction signs.
   7. Test/Inspection identification labels.
   8. Miscellaneous identification products.

1.2 COORDINATION


B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.4 ACTION SUBMITTALS

A. Product Data: For each electrical identification product indicated including labeling machines if used.

B. Shop Drawings:
   1. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification specific products.

C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:
   1. Brady USA, Inc. Industrial Products Division. All Weather Permanent type.
   2. BW Industries, Inc.
   3. Ideal Industries, Inc.
4. Rhino/DYMO, a Newell Rubbermaid Company.
5. Seton Name Plate Corporation.

2.2 REGULATORY REQUIREMENTS
B. Comply with NFPA 70 and NFPA 70E.
D. Comply with ANSI Z535.4 for safety signs and labels.
E. Adhesive attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

2.3 FONT
A. Arial uppercase.
B. Text abbreviations other than equipment identifications permitted only as approved.

2.4 BOX WIRING IDENTIFICATION MATERIALS
A. Self-Adhesive Labels: Field machine printed by thermal transfer or equivalent process with Panelboard Name, Panelboard Room Number, Voltage, System and Circuit No.

2.5 CONDUCTOR, WALL PLATE, AND COMMUNICATION AND CONTROL CABLE IDENTIFICATION MATERIALS
A. Color Coding Conductor Tape: Colored, self adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide. Tape shall not be used for conductor phase identification.
B. Marker Tapes: Vinyl or vinyl cloth, self adhesive wraparound type, with circuit identification text machine printed by thermal transfer or equivalent process.

2.6 FLOOR MARKING TAPE
A. 3 inch (75-mm) wide, 5 mil (0.12-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.7 UNDERGROUND RACEWAY MARKING TAPE
A. Provide heavy gauge, not less than 5 mils thick, by 6” (150 mm) wide, polyethylene marking tape with integral metallic detection foil applied therein:
   2. Wording: "CAUTION BURIED UTILITY LINE BELOW".
B. Acceptable Manufacturers:
   1. Seton.
   2. Panduit Corp.
   3. Emedco.
2.8 WARNING LABELS AND SIGNS
   B. Self Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
   C. Baked Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4 inch (6.4 mm) grommets in corners for mounting. Nominal size, 7 by 10 inches (180 by 250 mm).
   D. Metal Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396 inch (1 mm) galvanized-steel backing; and with colors, legend, and size required for application. 1/4 inch (6.4 mm) grommets in corners for mounting. Nominal size, 10 by 14 inches (250 by 360 mm).

2.9 INSTRUCTION SIGNS
   A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
      1. Engraved text with black letters on white face.
      2. Punched or drilled for mechanical fasteners.
      3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
   B. Electrical Assembly Single-Line:
      1. Framed acrylic screw mounted full size record drawing.
      2. Printed operating instructions may be included as an option to separate signage.

2.10 EQUIPMENT IDENTIFICATION LABELS
   A. Engraved, Laminated Acrylic or Melamine Label: Self Adhesive, color coded by system. Minimum letter height shall be 1/2 inch (6.4 mm).

2.11 EQUIPMENT TEST LABELS
   A. Adhesive Film Label: Machine printed, color coded by system, by thermal transfer or equivalent process. Minimum letter height shall be 1/2 inch (6.4 mm).

2.12 COMPONENT IDENTIFICATION LABELS
   A. Engraved, Laminated Acrylic or Melamine Label: Self-adhesive, color coded by system. Minimum letter height shall be 1/4 inch 93.2 mm).

2.13 CABLE TIES
   A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
      1. Minimum Width: 3/16 inch (5 mm).
      2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
      3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.
   1. Minimum Width: 3/16 inch (5 mm).
   2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
   3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
   1. Minimum Width: 3/16 inch (5 mm).
   2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 7000 psi (48.2 MPa).
   3. UL 94 Flame Rating: 94-V-0.
   4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
   5. Color: Red.

2.14 MISCELLANEOUS IDENTIFICATION PRODUCTS
A. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

2.15 ASSET TAG IDENTIFICATION SYSTEM
A. Refer to Asset Tag Spec Section.

PART 3 - EXECUTION

3.1 DESIGN CRITERIA
A. Provide electrical distribution branch color coding as follows:
   1. Normal:
      a. System ID or Nameplate: White
      b. Conductors: Per associated Section
   2. Generator:
      a. System ID or Nameplate: Yellow
      b. Conductors: Per associated Section
   3. Life Safety:
      a. System ID or Nameplate: Pink or Violet
      b. Conductors: Per associated Section
   4. Critical:
      a. System ID or Nameplate: Orange
      b. Conductors: Per associated Section
   5. Equipment:
      a. System ID or Nameplate: Green
      b. Conductors: Per associated Section

ELECTRICAL IDENTIFICATION

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6. **UPS:**
   a. System ID or Nameplate: Blue
   b. Conductors: Per associated Section

B. Provide text color to ensure legibility of label.

C. Refer to Division 27 and 28 specifications for systems color coding.

### 3.2 INSTALLATION

A. Verify identity of each item before installing identification products. Use Drawing nomenclature unless otherwise directed.

B. Location: Install identification materials and devices at locations shown on Drawings or for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach nonadhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

F. Box and Equipment Identification: Attach to box or enclosure cover in locations shown on Drawings or with high visibility.

G. Test and Inspection Identification: Attach to appropriate box, enclosure or device for most convenient viewing to operation and maintenance personnel. Install inside device door in finished areas.

H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
   1. Outdoors: UV-stabilized nylon.
   2. In Spaces Handling Environmental Air: Plenum rated.

I. Underground Raceway Marking Tape: Prior to backfilling of underground raceway, duct and ductbank trenches, install continuous length of underground marking tape directly above buried raceways, ducts and ductbanks, at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of raceways and ducts installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.

### 3.3 APPLICATION

A. Raceway Systems and Cables Identification:
   1. Raceways and Duct Banks More Than 600 V Concealed within Buildings: Identify with 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stencil text "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high black letters on 20-inch (500-mm) centers. Stop stripes at legends. Apply to the following finished surfaces:
      a. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
   2. Accessible Enclosures, Raceways and Cables More Than 600 V: Identify with "DANGER-HIGH VOLTAGE" in black letters at least 2 inches (50 mm) high, with self-adhesive vinyl labels. Repeat legend at 10-foot (3-m) maximum intervals.
3. Accessible Raceways, AC and MC Cables, 600 V or Less, for Service, Feeder, and Branch Circuits: Identify with self-adhesive vinyl label per NEC electrical distribution branch color coding including identification label. Install at box and conduit fittings within 12 inches, each side of joints, and at bushed conduits. Conduits 1” and larger exiting a panelboard shall be labeled with the contained circuit numbers within 12” of existing the enclosure.

4. Accessible Raceways and Cables of Division 23 through 28 Systems: Identify the systems with preprinted identification label, self-adhesive vinyl tape applied in bands per color coding. Install at box and conduit fittings within 12 inches, each side of joints, and at bushed conduits.
   a. Exception: No identification required for raceways and cable with readily identifiable terminations within the same room.

B. Box Identification:
   1. All boxes shall be labeled to indicate the information indicated below. Labeling shall be on the outside of the box cover and clearly visible. For boxes exposed in exterior areas, located identification inside box cover.
      a. Panelboard name.
      b. Panelboard location (room number).
      c. Voltage.
      d. Branch.
      e. Circuit numbers.
   2. Provide printed labels with legible color and text for all boxes. Label colors for each system shall be in accordance with 3.1A.

C. Conductor Identification:
   1. Phase Identification: Solid color insulation and/or jacket using the colors listed in Division 26 Section “Low Voltage Electrical Power Conductors and Cables (100-600 Volts)” for ungrounded conductors. Field applied color coding electrical tape on black conductors shall not be used.
   2. Feeder Conductor Identification: For conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes with more than one circuit use machine printed water and oil resistant labels. Identify source and circuit number of each set of conductors.
   3. Branch Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use marker tape. Identify each ungrounded conductor according to source and circuit number. Label each conduit/cable grouping with circuit numbers.
   4. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source and circuit number.
   5. Pull Wires in Empty Raceways: Tag pull wires at each end and in each intermediate box, manhole, or other enclosure identifying other end location using metal tags.
      a. Identify conductors, cables, and terminals within boxes, enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
      b. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
      c. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.
      d. Table of systems cable jacket color and labeling:
<table>
<thead>
<tr>
<th>System</th>
<th>Cable Function</th>
<th>Jacket color/printing</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAS</td>
<td>Binary Output (B.O.)</td>
<td>Violet</td>
</tr>
<tr>
<td>BAS</td>
<td>Binary Input (B.I.)</td>
<td>Orange</td>
</tr>
<tr>
<td>BAS</td>
<td>Analog Output (A.O.)</td>
<td>Tan</td>
</tr>
<tr>
<td>BAS</td>
<td>Analog Input (A.I.)</td>
<td>Yellow</td>
</tr>
<tr>
<td>BAS</td>
<td>Level 1 Network N1</td>
<td></td>
</tr>
<tr>
<td>BAS</td>
<td>Level 2 Network N2</td>
<td>Blue</td>
</tr>
<tr>
<td>BAS</td>
<td>24 Volt Power</td>
<td>Gray</td>
</tr>
<tr>
<td>BAS</td>
<td>Thermostat</td>
<td>White (Natural)</td>
</tr>
<tr>
<td>BAS/Fire Alarm</td>
<td>Damper Actuator Power</td>
<td>Red/&quot;ACTUATOR POWER FOR FIRE, SMOKE, FIRE/SMOKE DAMPERS&quot;</td>
</tr>
<tr>
<td>Fire Alarm</td>
<td>Signal</td>
<td>Red</td>
</tr>
<tr>
<td>Fire Alarm</td>
<td>Initiation</td>
<td>Red</td>
</tr>
<tr>
<td>Fire Alarm</td>
<td>Notification</td>
<td>Red</td>
</tr>
</tbody>
</table>

D. Wiring Device and Coverplate Identification:

1. General:
   a. Wiring devices and coverplates shall be provided with specific identification.
   b. Identification to be located on both front and back of coverplate.
   c. ID shall be not less than 1/8 inch tall, uppercase letters and numerals.
      1) ID may be machine printed, self-adhesive backed tape, or labels.

2. Wiring Devices:
   a. All receptacles and lights switches shall be labeled with the following branch circuit source information:
      1) Panelboard name.
      2) Panelboard room location.
      3) Circuit number.
      4) Example: “1LSL1(RM 1234) CKT #15, 17”
   b. Where more than 3 lighting control devices are ganged together at a common location, under a single coverplate, provide machine printed, self adhesive type ID, on face of coverplate, specifically identifying the luminaire group, or area, the devices control.
   c. In addition to the other previously specified ID information, receptacles connected to patient headwall bedstop relays shall be provided with the word "BED" also machine printed on face of coverplate.
   d. In addition to the other previously specified ID information, receptacles serving dialysis equipment shall be provided with the words "DIALYSIS ONLY" also machine printed on face of coverplate.
   e. Coverplates for fractional horsepower manual motor starters shall be provided with machine printed ID on face reading "DISCONNECT - EQUIPMENT DESIGNATION". Example: DISCONNECT – EXH. FAN EF01. In addition, provide Panelboard name, panelboard room number and circuit number.

E. Warning Tapes, Labels, and Signs:
1. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway.

2. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush mounted panelboards and similar equipment in finished spaces.

3. Warning Labels for Identification for Branch Circuit Ungrounded Conductors: Install at all branch circuit panelboards, cabinets, and enclosures per NFPA 70. Apply to interior of door, cover, or other access generally.
   a. For 208/120 volt systems, lines and text shall be:
      1) "208/120 VOLT SYSTEM"
      2) "PHASE A – BLACK"
      3) "PHASE B – RED"
      4) "PHASE C – BLUE"
   b. For 480/277 volt systems, lines and text shall be:
      1) "480/277 VOLT SYSTEM"
      2) "PHASE A – BROWN"
      3) "PHASE B – ORANGE"
      4) "PHASE C – YELLOW"
   c. For isolated power systems, lines and text shall be:
      1) For single phase 120V isolated power systems, lines and text shall be:
         a) "120 VOLT ISOLATED POWER SYSTEM"
         b) "Conductor No. 1 – ORANGE"
         c) "Conductor No. 2 – BROWN"
      2) For three phase 208V isolated power systems, lines and text shall be:
         a) "208 VOLT ISOLATED POWER SYSTEM"
         b) "Conductor No. 1 – ORANGE"
         c) "Conductor No. 2 – BROWN"
         d) "Conductor No. 3 – YELLOW"

4. Warning labels and signs shall include, but are not limited to, the following texts:
   a. Low Voltage Room Door Sign: "DANGER-ELECTRICAL HAZARD – AUTHORIZED PERSONNEL ONLY".
   b. Medium Voltage Equipment and Raceway Access Label: "DANGER – HIGH VOLTAGE."
   c. Medium Voltage Room Door Sign: "DANGER – HIGH VOLTAGE – KEEP OUT."
   d. Service Disconnect Sign: "SERVICE DISCONNECT."
   e. Service Disconnect Sign: "AVAILABLE SERVICE FAULT CURRENT = XXXX/DATE: XX/XX/XX" per the coordination study in Division 26 Section "Protective Device Coordination".
   f. Generator Disconnect Sign: "GENERATOR XX DISCONNECT."
   g. Fire Pump Disconnect Sign: "FIRE PUMP DISCONNECT."
   h. Multiple Power Source Warning (locate at each service and generator disconnect equipment): "DANGER – ELECTRICAL SHOCK HAZARD – EQUIPMENT HAS MULTIPLE POWER SOURCES. STANDBY POWER SOURCE LOCATED IN _______ ROOM LOCATED AT _______ AREA OF BUILDING."
i. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and baked-enamel warning signs. Identify system voltage with black text on an orange background. Apply to exterior of door, cover, or other access.

1) Equipment with Multiple Power or Control Sources: Apply to front of equipment including, but not limited to, the following:
   a) Transfer switches.
   b) Controls with external control power connections.

j. Fused and Non-Fused Motor Disconnect Switches: Install baked enamel warning sign with white legend on red background with minimum 3/8 inch high lettering with the following designation – "DANGER, DO NOT USE TO START OR STOP MOTOR. USE FOR ISOLATION ONLY."

k. Back-Fed Switches and Circuit Breakers: Where switches and devices such as knife switches, circuit breakers, molded-case switches, and contactors are installed such that the load side of the switch device could energize with the switch open due to back feeding, provide a warning plate with the wording "WARNING – LOAD SIDE OF SWITCH MAY BE ENERGIZED BY BACKFEED", shall be installed on the switch.

l. Arc Flash Hazard Warning: Per NFPA 70 requirements.

F. Instruction Signs:

1. Operating Instructions: Install engraved instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation. Equipment requiring instructions shall include but not be limited to:
   a. UPS with Bypass
   b. Switchgear Automatic Throw-Over (ATO)
   c. Switchgear Main-Tie-Main

2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer, load shedding, key interlocks or emergency operations.

3. Electrical Assembly Single-Line: Install at end of assembly having no future extension provisions or as otherwise shown on Drawings within sight of assembly.

G. Equipment Identification Labels:
1. Apply equipment identification labels of engraved, laminated acrylic or melamine label on each major unit of electrical equipment in building, including central or master unit of each electrical system. This includes communication/signal/alarm systems, unless unit is specified with its own self-explanatory identification. Except as otherwise indicated, provide single line of text in field designating the equipment served. Provide colored labels to identify the equipment by electrical distribution branch using the colors reference in Section 3.1A above. Text shall match terminology and numbering of the Contract Documents and shop drawings. Electrical equipment nameplates shall also designate the voltage and line side source (i.e. FED FROM: PANEL "_______", CKT # "____" ROOM # "____") in smaller 1/8 inch (3.2 mm) text. Smaller nameplate text may be used where adequate nameplate mounting space is not available, but in no case shall the text be smaller than 1/8-inch (3.2 mm). Apply adhesive labels for each unit of the following categories of electrical equipment and those scheduled on Drawings for electrical equipment and panelboard designations. Transfer switches shall include three (3) labels; emergency and normal source and load identification text. Three-phase equipment shall also include identification of the phase rotation.

   a. Automatic transfer switch.
   b. Battery chargers.
   c. Boxes (Pull, Junction, or Branch Circuit) when given specific designation on Drawings.
   d. Busway plug-in units.
   e. Central battery inverter systems.
   f. Communication/special systems cabinets and backboards.
   g. Contactors.
   h. Control devices.
   i. Disconnect switches.
   j. Distribution panelboards protective devices.
   k. Emergency generator control system relays and protective devices.
   l. Emergency power off (EPO) stations.
   m. Fire alarm system field processing units, terminal cabinets, peripheral monitor and control addressable relay modules, fire phone cabinets and remote duct detector test stations.
   n. Ground buses and terminal bars.
   o. Isolated power panels.
   p. Key interlock spares cabinet.
   q. Lighting control cabinets.
   r. Low voltage relay panels.
   s. Load interrupter switches.
   t. Metering equipment.
   u. Motor control centers:
      1) Designate integral motor function (i.e. "CW Pump P-1"), not "P-1."
   v. Motor controllers:
      1) Designate motor function (i.e. "CW Pump P-1"), not "P-1."
   w. Main overcurrent device or main lug section and motor controllers in motor control centers.
   x. Other systems.
   y. Panelboards.
      1) Designate the electrical distribution branch (i.e. “Normal”, “Life Safety”, etc.).
2) Designate the voltage (i.e. 208Y/120V).
3) Designate the fed from Source and room number of the source.

z. Pushbuttons.
   aa. Strip terminal cabinets.
   bb. Separately mounted motor controllers.
   cc. Single-pole switches and fractional horsepower manual starters used for motor disconnect switch.
   dd. Spare fuse cabinet.
   ee. Surge protection devices.
   ff. Switchboards and associated protective devices.
      1) Designate the electrical distribution branch (i.e. “Normal”, “Life Safety”, etc.).
      2) Designate the voltage (i.e. 208Y/120V).
      3) Designate the fed from Source and room number of the source.

gg. Switchgear and each front cover device in a switchgear lineup.
   1) Designate the electrical distribution branch (i.e. “Normal”, “Life Safety”, etc.).
   2) Designate the voltage (i.e. 208Y/120V).
   3) Designate the fed from Source and room number of the source.

hh. Separately mounted circuit breakers.
   ii. Transfer switch.
   jj. Transformers.
   kk. Unit substations.
   ll. Control Power Transformers (See additional schedule required below)

2. Refer to appropriate sections for other identification marking requirements and nomenclature.
3. Attach identification after finish painting.
4. Refer to sample label sheets following this section.

H. Component Identification Labels:
1. Apply component identification labels to distribution panelboard, switchgear, unit substation, switchboard, and MCC assemblies as follows:
   a. Assembly Nameplate: Apply per equipment identification label requirements except 1-inch (80 mm) identification text.
   b. Cubicle Label: Apply 1/2-inch (40 mm) black text on white plate identifying left-to-right number with 1/4-inch (20 mm) black text below identification section type(s):
      1) Pull.
      2) Main Circuit Breaker.
      3) Tie Breaker.
      4) Utility Metering.
      5) Customer Metering.
      6) Transformer # XX.
      7) Distribution #XX.
      8) Main Lugs.
      9) Transition.
     10) Transfer Switch.
     11) Bolted Pressure Switch.
     12) Battery.
     13) Panelboard.
     14) Inverter.
15) Rectifier/Charger.
16) Static Switch.
17) Bypass Switch.
18) Auxiliary.
19) Rotary Power Unit (RPU).
20) Circuit Breaker.
21) Tie Breaker.
22) Spare.
23) Space.
24) Motor Controller.
25) MV Feeder #XX.

c. Protective Device Load Label: Apply 1/4-inch (20 mm) text on plate per system color coding identifying load served. For medium voltage feeders, also identify "FEEDER NO. XX"

d. Miscellaneous Component Labels: Apply 1/4-inch (20 mm) black text on white plate identifying components and instruments mounted on front or within the assembly such as relays, fuses, switches, terminal blocks.

I. Equipment Test Labels:
1. Apply equipment test labels of adhesive film label on each major unit of electrical equipment and components identified to be tested in Division 26 Section "Electrical Inspections and Testing" and associated Sections, after satisfactory completion of tests and inspections.
2. Indicate test results, responsible agency, representative and date.
3. For bar coded equipment, also provide test data within equipment software menu.

J. Asset Tag Labels:
1. Apply asset tag labels to:
   a. All electrical equipment receiving labels.
3.4 SAMPLE LABELS:

A. Panelboards:
B. Junction and Pull Box Labels:

![Image of pull box labels]

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C. Load Labels:

### Disconnect 9TN1

<table>
<thead>
<tr>
<th>Branch</th>
<th>Room Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>H9251</td>
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Voltage, Phase, Wires: 480v, 3 Phase, 3 Wire

Source: MSWBDMH1

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<tr>
<th>Source Circuit #</th>
<th>Source Location</th>
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<tr>
<td>25-27-29</td>
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### EF - CFAC - 5A

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<th>Branch</th>
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<tr>
<td>Critical</td>
<td>HM100</td>
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Voltage, Phase, Wires: 480v, 3 Phase, 3 Wire

Source: MLEH2

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<tbody>
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<td>31 - 33 - 35</td>
<td>HM100</td>
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### Disconnect 9TC1

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<th>Room Number</th>
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<td>Critical</td>
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</tbody>
</table>

Voltage, Phase, Wires: 408v, 3 Phase, 3 Wire

Source: MSWBDC1

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<th>Source Location</th>
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### D. Transfer Switches:

**1ATSE8**

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<th>Room Number</th>
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<tbody>
<tr>
<td>Normal</td>
<td>H1114</td>
</tr>
</tbody>
</table>

**Voltage, Phase, Wires**

480/277v, 3 Phase, 4 Wire

**Source**

1USSHV1

<table>
<thead>
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<th>Source Circuit #</th>
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**Voltage, Phase, Wires**

480/277v, 3 Phase, 4 Wire

**Source**

1LVSG1

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**Voltage, Phase, Wires**

480/277v, 3 Phase, 4 Wire

**Load**

MPEH4

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E. Major Unit Electrical Equipment:

F. Devices:

1LNPL(Rm3803)
Ckt #15,17

G. Control Power Transformer Schedule:

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SECTION 260573 - PROTECTIVE DEVICE COORDINATION STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes computer based voltage protective device coordination studies, associated reports and the setting of these devices. Studies include:

1. Fault Current.
2. Coordination.
3. Arc Flash Hazard.
4. Project state registered Professional Engineer seal and signature.

B. Series ratings of protective devices are not acceptable.

C. Requirements of Division 26 Sections apply to this Section for electrical distribution systems, electrical identification, and general requirements.

D. Contractor to procure current FH coordination study files from FH EFS dept (files will be in SKM software format). After completion of project updates files are to be returned to FH EFS dept in SKM file format.

1.2 COORDINATION OF WORK

A. Adjustment or replacement of protective device equipment to meet the approved protective device coordination submittal shall be the responsibility of Division 26 at no additional cost.

1. Coordinate Submittal Schedule:

a. Submittals of protective device equipment shall be subject to the approval of the protective device coordination submittal, even if not so noted or commented on those protective device equipment submittals. The coordination responsibility remains with Division 26.

b. The protective device coordination submittal shall be submitted prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing.

c. Proceed with coordination study and arc flash study only after relevant equipment submittals have been assembled. Protective devices not submitted for approval with coordination study may not be used in study. Protective devices submitted prior to this coordination study will be reviewed, but final approval contingent upon this study results.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract, Division 01 Specification Sections, and Division 26 Section "Basic Division 26 Requirements".

1.4 ACTION SUBMITTALS

A. Product Data:

1. For computer software program used for the studies.
2. For protective devices used in the study, include coordination charts, tables and related data.
   a. Time-current curves unreadable due to too much or too little required information will be rejected.

B. Delegated Design Services:
   1. Study/Calculations.
   2. PE Stamp.

C. Protective Device Coordination Studies Report:
   1. Executive Summary.
   2. Introduction:
      a. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

   3. Single Line Diagram, showing the following:
      a. Equipment designations to match Contract Documents.
      b. Protective device ratings and recommended settings.
      c. Conductor, busway and raceway sizes, lengths and types.
      d. Transformer ratings and recommended tap settings.
      e. Motor and generator ratings.
      f. Switchgear, switchboard, motor control center, and panelboard ratings.


   5. Fault Current Study:
      a. Low Voltage Fault Report: Three phase and unbalanced fault calculations, showing the following for each overcurrent device location:
         1) Voltage.
         2) Calculated fault current magnitude and angle.
         3) Fault point X/R ratio.
         4) Equivalent impedance.
      b. Momentary Duty Report: Three phase and unbalanced fault calculations, showing the following for each overcurrent device location:
         1) Voltage.
         2) Calculated symmetrical fault current magnitude and angle.
         3) Fault point X/R ratio.
         4) Calculated asymmetrical fault currents:
            a) Based on fault point X/R ratio.
            b) Based on calculated symmetrical value multiplied by 1.6.
            c) Based on calculated symmetrical value multiplied by 2.7.
      c. Interrupting Duty Report: Three phase and unbalanced fault calculations, showing the following for each overcurrent device location:
         1) Voltage.
         2) Calculated symmetrical fault current magnitude and angle.
         3) Fault-point X/R ratio.
         4) No AC Decrement (NACD) ratio.
         5) Equivalent impedance.
6) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
7) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.


6. Coordination Study:
   a. Time Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
      1) Device tag and title, one line diagram with legend identifying the portion of the system covered.
      2) Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
      3) Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
      4) Plot the following listed characteristic curves:
         a) Power utility's overcurrent protective device.
         b) Medium voltage equipment overcurrent relays.
         c) Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
         d) Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands.
         e) Transformer full load current, magnetizing inrush current, and ANSI through fault protection curves.
         f) Cables and conductors damage curves.
         g) Ground fault protective devices.
         h) Motor starting characteristics and motor damage points.
         i) Generator short circuit decrement curve and generator damage point.
         j) The largest feeder circuit breaker in each motor control center and panelboard.
      5) Provide adequate time margins between device characteristics such that selective operation is achieved.
   b. Report recommended settings of protective devices ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
      1) Phase and Ground Relays:
         a) Device tag.
         b) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
         c) Recommendations on improved relaying systems, if applicable.
      2) Circuit Breakers:
         a) Adjustable pickups and time delays (long time, short time, ground).
         b) Adjustable time-current characteristic.
c) Adjustable instantaneous pickup.
d) Recommendations on improved trip systems, if applicable.

3) Fuses: Show current rating, voltage, and class.

c. Equipment Evaluation Report:
1) Comments and recommendations for system improvements.

7. Arc Flash Hazard Analysis:
a. Incident Energy and Flash Protection Boundary Calculations:
1) Arcing fault magnitude.
2) Protective device clearing time.
3) Duration of arc.
4) Arc flash boundary.
5) Working distance.
6) Incident energy.
7) Hazard risk category.
8) Recommendations for arc flash energy reduction.

b. Owner Equipment Recommendations.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For coordination study and arc flash study, specialist who shall be a professional engineer registered in the state of the project and names of at least three (3) similar studies performed over the past year.

1. Demonstrate capabilities in providing equipment, services, and training to reduce Arc Flash exposure and train workers in accordance with NFPA 70E and other applicable standards.
2. Demonstrate experience in providing equipment labels in compliance with NEC Section 110 and ANSI Z535.4 to identify AFIE and appropriate Personal Protective Equipment classes.

B. Miscellaneous Submittals: Submittals for system certification, testing, and record drawings shall be per Division 01.

C. Submittals to Authorities Having Jurisdiction: In addition to distribution requirements for submittals specified in Division 01 Section "Submittals," make an identical submittal to authorities having jurisdiction. To facilitate review, include copies of annotated Contract Drawings as needed to depict component locations. Resubmit if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Engineer for review.

1.6 CLOSEOUT SUBMITTALS

A. Record Documents:

1. Approval and Acceptance: Provide the "Record of Completion" form according to NFPA 70 to Owner, Engineer, and authorities having jurisdiction.
2. Record of Completion Documents: Provide the "Permanent Records" according to NFPA 70 to Owner, Engineer, and authorities having jurisdiction.
   a. Hard copies on paper to Owner (3), Engineer (1), and authorities having jurisdiction (1).
b. Complete Buildings Record Drawings: Coordinate through the Construction Manager a complete set of record drawings depicting as-left protective device settings.

c. Electronic copy of all record documents in PDF format.

d. Electronic copies of the working data (SKM) files for the analysis software used for the calculations.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Fault Current Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society’s Certified Software Development Professional certification.

C. Coordination Study and Arc Flash Study Specialist Qualifications: An organization experienced in the application of computer software used for electrical short circuit analysis and coordination studies having performed successful studies of similar magnitude on electrical distribution systems using similar devices. The coordination study shall be performed under the supervision of a project state registered professional electrical engineer, in accordance with ANSI/IEEE Standard 242, "Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems."

D. Field Data Gathering Qualifications:

1. Gather and tabulate the following input data to support protective devices studies:

   a. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

E. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association to supervise testing specified in Part 3.

F. Comply with ANSI/NETA ATS – Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems for study requirements and field testing.

1. Perform study, as required by this Section, Division 26 Section "Basic Division 26 Requirements", and ANSI/NETA ATS "Power System Studies" requirements.

   a. Follow-up thermographic survey shall not be required.

   b. Prepare test and inspection reports.

G. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:


2. General Electrical Field Quality Control.

PART 2 - PRODUCTS

2.1 ACCEPTABLE STUDY PROVIDERS
A. Protective Device Coordination Studies Provider: Subject to compliance with requirements, study shall be commissioned by Division 26.

2.2 WORK RESULTS
A. The study shall include all new distribution equipment supplied under this contract.
B. Devices to be included in this study shall include all components downstream of the utility company and generator plant service(s) and with special attention given to coordinating with existing distribution devices.
C. The study shall include all new distribution equipment under this contract as well as all directly affected existing distribution equipment at the facility connection points. Make necessary new and existing protective device adjustments.
D. Include associated utility company requirements.
E. Exclude selective coordination of an existing emergency system branch which is untouched and assumed grandfathered per codes at time of install.
F. Study all cases of systems switching configurations and generator plant operations that could result in maximum fault or other derangement conditions.

2.3 REGULATORY REQUIREMENTS
A. Comply with NFPA 99 and NEC articles 620, 700, 701, 708 and 517 for selectivity requirements.
B. Comply with IEEE 399 for general study procedures.
C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.
D. Comply with IEEE 1584 for arc flash calculation guidelines.

2.4 COMPUTER SOFTWARE DEVELOPERS
A. The studies are to be performed in SKM System Analysis Power Tools.

2.5 COMPUTER SOFTWARE PROGRAM REQUIREMENTS
A. The studies are to be performed in SKM System Analysis Power Tools.
B. Comply with IEEE 399 and IEEE 551.
C. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399, Table 7-4.
D. Computer software program shall provide plotting and diagramming time-current characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices.
   1. Additional Program Features:
      a. Arcing faults.
      b. Simultaneous faults.
      c. Explicit negative sequence.
d. Mutual coupling in zero sequence.
e. Arc flash hazard analysis.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine project medium and low voltage protective device submittals for compliance with electrical distribution system coordination and arc flash requirements and other conditions affecting performance.

3.2 PREPARATION - POWER SYSTEM DATA

A. Obtain all data necessary to conduct the overcurrent protective device studies.

1. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
2. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.
3. Comply with recommendations in IEEE 241 and IEEE 551 for the amount of detail required to be acquired in the field.

B. Gather and tabulate input data to support the protective device coordination studies:

1. Equipment Data:
   a. Use equipment designation identification tags that are consistent with the Contract Documents and report single line diagram.
   b. Full load current load data.
   c. Special load considerations, including motor starting inrush currents and frequent starting and stopping. Include motor X/R ratios for all elevators and motors 50 HP and greater.
   d. Product data sheets enforcing the single line diagram data including:
      1) Time current curves.
      2) Equipment manufacturers, types, ratings, plugs, and adjustable setting ranges.
   e. New Equipment Product Data:
      1) Submittal data.
         a) Include protective devices specified in Division 26 or other Divisions.
   f. Existing Equipment Data:
      1) Maximum demand from the service meters.
      2) Conductor and raceway type, materials and size.
      3) Ratings at each study bus:
         a) Voltage.
         b) Full load current.
         c) Short circuit current.
         d) Withstand current.
4) Equipment manufacturer, model, and product data appropriate to the study requirements.

2. Source Data:
   a. Power sources and ties with understanding of the modes of potential operation.
   b. Electric utility company’s protective devices types, ratings, and settings.
      1) Special electric utility company protective device stipulations and settings.

3. Source Impedance Data:
   a. Electric utility company’s fault current contribution at the point of service.
   b. Full fitout generator plant fault current contribution. Include future generator(s) contribution based upon identical set(s) to the new generator sets.
   c. Include motor fault contribution characteristics.
   d. Include impedance X/R ratios.

4. Distribution Data:
   a. Electrical distribution system diagrams, new and existing overcurrent protective device submittals, input and output data, and recommended device settings.
   b. Short circuit current at each system bus, three phase, and line-to-ground.
   c. Full load current of all loads.
   d. Data sheets to supplement electrical distribution system diagram, cross referenced with tag numbers on diagram, showing the following:
      1) Electric Utility Data:
         a) Ratings, types, and settings of utility company's overcurrent protective devices.
         b) Special overcurrent protective device settings or types stipulated by utility company.
         c) Electric Utility Company source impedance data.
      2) Special operating mode and load considerations, including starting inrush currents and frequent starting and stopping.
      3) Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
      4) Motor full load current, locked rotor current, service factor, starting time, type of start, and thermal damage curve.
      5) Generator thermal damage curve. Refer to Division 26 Section "Engine Generator Sets" for generator protection requirements.
      6) Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long time adjustment range, short time adjustment range, and instantaneous adjustment range for circuit breakers.
      7) Manufacturer and type, ampere tap adjustment range, time delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
      8) Panelboards, switchboards, motor control center ampacity, and SCCR in amperes rms symmetrical.
      9) Identify series rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.
3.3 FAULT CURRENT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. Begin short circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:
   1. To normal system low voltage load buses where fault current is 10 kA or less.

E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system switching configurations and alternate operations that could result in maximum fault conditions.

F. The calculations shall include the ac fault current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low and medium voltage, three phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
   1. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three phase bolted fault short circuit study.

G. Calculate short circuit momentary and interrupting duties for a three phase bolted fault at each of the following:
   1. Electric utility company’s supply termination point.
   2. Incoming switchgear.
   3. Unit substation primary and secondary terminals.
   4. Low voltage switchgear.
   5. Motor control centers.
   6. Control panels.
   7. Standby generators and automatic transfer switches.
   8. Branch circuit panelboards.
   9. Disconnect switches.

H. Calculate momentary and interrupting duties on the basis of maximum available fault current.

I. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with the following:
   2. Low Voltage Fuses: IEEE C37.46.

J. Study Report: Enter calculated X/R ratios and interrupting (5-cycle) fault currents on single line diagram of the report. List other output values from computer analysis, including momentary (1/2-cycle), interrupting (5-cycle), and 30-cycle fault-current values for 3-phase, 2-phase, and phase to ground faults.

K. Equipment Evaluation Report: Prepare a report on the adequacy of protective devices and conductors by comparing fault current ratings of these devices with calculated fault current momentary and interrupting duties. Describe adequacy of electrical equipment to withstand short circuit stresses.
3.4 COORDINATION STUDY

A. Perform coordination study and prepare a written report using the results of fault current study approved computer software program, and manufacturer’s selectivity tables when necessary.

B. Comply with NFPA 70 for overcurrent protection of circuit elements and devices. Overcurrent protection devices on the Life Safety Branch shall be selectively coordinated with their supply side for all fault durations. Devices on the Normal, Critical, and Equipment branches shall be selectively coordinated for the period of time that a fault’s duration exceeds 0.1 seconds.

C. Comply with IEEE 141 and IEEE 242 time intervals.

D. Transformer Primary Overcurrent Protective Devices:
   1. Device shall not operate in response to the following:
      a. Inrush current when first energized.
      b. Self-cooled, full-load current or forced air cooled, full load current, whichever is specified for that transformer.
      c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
   2. Device shall protect transformer according to IEEE C57.12.00, for fault currents.

E. Motor Protection:
   1. Select protection for low voltage motors according to IEEE 242 and NFPA 70.
   2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

F. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, IEEE 45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum fault current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and fault current.

G. Generator Protection: Select protection according to manufacturer’s written recommendations and to IEEE 242.

H. Coordination Study Report: Prepare a written report indicating the following results of the coordination study.
   1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
      a. Device tag.
      b. Relay current transformer ratios; and tap, time dial, and instantaneous pickup values.
      c. Circuit breaker sensor rating; and long-time, short-time, and instantaneous settings.
      d. Fuse current rating and type.
      e. Ground fault relay pickup and time delay settings.
   2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between series devices, including power utility company’s upstream devices. Show the following specific information:
      a. Device tag.
      b. Single line reference schematic diagram.
      c. Voltage and current ratio for curves.
      d. Three phase and single phase damage points for each transformer.
e. No damage, melting, and clearing curves for fuses.
f. Cable damage curves.
g. Transformer inrush points.
h. Maximum fault current cutoff point.
i. Generator short circuit decrement curve and generator damage point.

3. Completed data sheets for setting of overcurrent protective devices.
4. Equipment Evaluation Report: Study shall include a narrative identifying any potential coordination short falls and recommendations for change.

3.5 LOAD FLOW AND VOLTAGE DROP STUDY
A. Perform a load flow and voltage drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:
1. Determine load flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
2. Determine load flow and voltage drop based on 80 percent of the design capacity of the load buses.
3. Prepare the load flow and voltage drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.6 PROTECTIVE DEVICE SETTING
A. Manufacturer’s Field Service: Engage a factory authorized service representative, of electrical distribution equipment being set and adjusted, to assist in setting of overcurrent protective devices within equipment.

3.7 ARC FLASH HAZARD ANALYSIS
A. Comply with NFPA 70E and its Annex D for hazard analysis study.
B. Use the fault current study output and the field verified settings of the overcurrent devices.
C. Calculate maximum and minimum contributions of fault current size:
1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
2. The maximum calculation shall assume a maximum contribution from the utility and generator plant and shall assume motors to be operating under full load conditions.
D. Calculate the arc flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
E. Include medium and low voltage equipment locations, except 240V ac and 208V ac systems fed from transformers less than 125 kVA.
F. Safe working distances shall be specified for calculated fault locations based on the calculated arc flash boundary, considering incident energy of 1.2 cal/sq. cm.
G. Incident energy calculations shall consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
1. Fault contribution from induction motors should not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc flash computation shall include both line and load side of a circuit breaker as follows:
   1. When the circuit breaker is in a separate enclosure.
   2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

J. Field Labeling and Signage:
   1. Provide complete arc flash hazard warning signage per NFPA 70 Article 110-16 at each new or modified switchgear, switchboard, panelboard, MCC, ATS, and other electrical distribution equipment.
   2. Comply with Division 26 Section "Electrical Identification" for warning labels and signs.
      a. Coordinate with Electric Utility Company and provide available fault current warning sign in compliance with NEC.
   3. Calculated available fault current values and date calculated shall be entered:
      a. Into the FH Master One Line
      b. Into each panel schedule file and printed schedule.

K. Owner Equipment Recommendations:
   1. Provide complete personal protective equipment (PPE) recommendations for each location and class.
   2. Provide three (3) manufacturer’s data and contacts for each class of personal protective equipment for their purchase consideration.

3.8 FIELD QUALITY CONTROL

A. Inspection and Tests:
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS "Power Systems Studies", Sections for associated study components, "System Functional Tests", and "Thermographic Survey" requirements, and the following additional requirements:
      a. Follow-up thermographic survey shall not be required.
      b. Prepare test and inspection reports.

END OF SECTION 260573
SECTION 260575 - CONDUIT ROUGH-IN SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes Conduit Rough-In Systems and pathways for communication and signaling systems cabling and boxes including all work incidental thereto as shown on Drawings and specified.

1.2 DEFINITIONS
   A. Pathway: Routing of cabling from device outlet box to system cabinet or rack. Pathways may consist of outlet boxes, cabinets, surface raceways, conduit, conduit stub, conduit sleeve(s), cable tray, J-Hooks, etc. where system cabling will be run.
   B. Rough-In: Preparation for system(s) cabling and equipment installations.
   C. System Cabling: Low voltage signal and control cabling. System cabling is designated by the manufacturer for a particular system in each specification section.

1.3 COORDINATION
   A. Coordinate all requirements of the Owner’s and manufacturer’s representatives for all room preparation, pathways and specific rough-in installation requirements, including associated sizing, location and labeling, for the following systems:
      1. Division 02 - 25 Systems:
         a. Power for equipment furnished under these Divisions.
      2. Division 23 Systems:
         a. Instrumentation and Control for HVAC.
      3. Division 26 Systems:
         a. Electric Power Management.
         b. Automatic Line Voltage Lighting Control Equipment.
         c. Lighting Control Equipment.
         d. Lighting Dimming.
         e. Wallbox Preset Dimming.
      4. Division 27 Systems:
         a. Structured Telecommunications Cabling.
         b. Nurse Call.
         c. Door Entry Intercom.
         d. Intercom.
         e. Broadband Television Distribution.
         f. Public Address.
         g. Master Clock.
         h. Digital Broadband Video Distribution.
         i. Audio Visual Cabling.
      5. Division 28 Systems:
         a. Fire Alarm.
         b. Fire Department In-Building Wireless Radio.
c. Access Control / Intrusion Detection.
d. Protective Services CCTV Distribution.
e. Video Surveillance.

6. Owner Supplied Systems:
   a. Surgical Service Booms: Refer to resource drawings provided by the surgical service boom unit supplier for device rough-in, pathways and wiring requirements.
   b. Diagnostic and Treatment Room Equipment Rough-In: Refer to resource drawings provided by the equipment supplier for rough-in, pathways and wiring requirements.
   c. Coordinate Owner supplied systems rough-in materials with the requirements defined in Division 26 sections.

B. Coordinate equipment backboard installations including:
   1. Meet Owner’s and manufacturer’s representative layout requirements.
   2. Ensure that installer:
      a. Provides spacers between wall and backboard to support and locate intended equipment.
      b. Locates backboard 6 inches above finish floor level around room.
      c. Paints backboard on all sides with appropriate paint.
      d. Allows for flush rough-in of wiring devices.
      e. Allows for cable management and slots behind backboards.
      f. Allows for signal grounding bus installations per Division 26 Section "Grounding and Bonding."

C. Coordinate sleeves for pathways and cable per Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling".

1.4 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.5 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Provide per "Basic Division 26 Requirements." Include:
   1. Details for all identified systems equipment rooms including, but not limited to those rooms labeled:
      a. Cable Pull.
      b. Communications.
      c. Data.
      d. Network.
      e. MDF.
      f. Server.
      g. Tel/Data.
      h. Telecommunications.
   2. Floor plans for each system local equipment room service area depicting:
      a. Cabling pathways, color coding and field equipment, identification labels.
      b. Specific equipment, outlet and patching identification labels.
   3. Sign-offs of Owner’s and manufacturer’s representatives for each document submitted.
CLOSEOUT SUBMITTALS

A. Record Documents:
   1. Submit updated Coordination Drawings as Record Documents.

PART 2 - PRODUCTS

2.1 OUTLET BOXES

A. Flush wall mounted.
   1. Utilize 4 inch square, 2-1/8 inch deep backbox.
   2. Utilize 3-5/8 inch deep tile box for block or brick wall construction.

B. Mullion Mounted Devices:
   1. Flush backbox or open ring as recommended by device manufacturer for installation in metal door frame/aluminum door frame as shown on Drawings.
   2. Coordinate installation and conduit access with door frame and door hardware manufacturer’s for cabling routing and connectivity.

C. Cable Bushings:
   1. Provide plastic bushings at grommet of outlet box where open cabling installation is allowed to directly enter outlet box (in ceiling spaces).

2.2 REGULATORY REQUIREMENTS

A. Comply with the following Standards and Codes:
   1. ANSI/EIA/TIA – 568B: Commercial Building Telecommunications Cabling Standard
   2. ANSI/EIA/TIA – 569B: Commercial Building Standard for Telecommunications Pathways and Spaces
   4. ANSI-J-STD-607-A: Commercial Building Grounding, Earthing and Bonding Requirements for Telecommunications
   5. ANSI/NECA/BICSI 568-2001: Installing Commercial Building Telecommunications Cabling
   6. NFPA 70 National Electrical Code
   7. All addenda, technical service bulletins, etc., associated with the above reference standards.

2.3 PLASTER COVER

A. Single gang, galvanized steel, for single gang device.

B. Two gang, galvanized steel, for two gang device.

2.4 COVER PLATES

A. Same material, finish and color as for wiring devices. Refer to Division 26 Section "Wiring Devices."

B. Single gang for single device with appropriate opening, split plate, etc. for device to be installed.

C. Two gang as required for system outlets.

CONDUIT ROUGH-IN SYSTEMS

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D. Device opening shall be bushed one-inch when used for wire pull.
E. Blank as shown on Drawings or when single device type not used.

2.5 RACEWAYS
A. Refer to Division 26 Section "Raceways" for requirements.
   1. Provide with insulated throats and bushings on all conduit runs, stubs, and sleeves.

2.6 SLEEVES
A. Refer to Division 07 and Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling" for firestopping requirements.

2.7 CABLE J-HOOKS
A. Metallic J-hook bracket (1-1/2 inches wide) with cable retainer or Velcro strap, wall or support rod mounted.
   1. Provide system manufacturer recommended fasteners.
B. Category 6A compliant.
C. Acceptable Manufacturers/Series:
   1. Caddy Cat. 32 Series.
   2. B-Line BCH32 Series.
   3. Mono Systems The Hook™
   4. Or Approved Equivalent.

2.8 CABLE TRAY
A. Refer to Division 27 for cable tray requirements.

2.9 EQUIPMENT BACKBOARDS
A. Refer to Division 06 for plywood equipment backboard requirements.

2.10 CABLE DISTRIBUTION SPOOLS FOR BACKBOARDS
A. Fire-retardant, high strength composite material.
B. 1-1/2 inch length.
C. Promotes compliance with T568B bend radius (4 x cable diameter).

2.11 CABINETS AND COMMUNICATION RACKS
A. Refer to Division 26 Section "Boxes and Cabinets" for cabinet requirements.
B. Refer to Division 27 Section "Communications Cabinets and Racks" for communications type rack assemblies.
PART 3 - EXECUTION

3.1 CONDUIT AND PATHWAYS APPLICATIONS

A. Conduit Raceways (Completely Enclosed Wiring):
   1. Shall be used for separate and independent horizontal system cabling routing for each of the following systems:
      a. Division 02 – 25 Systems:
         1) Rated smoke control system cabling
         2) Med Gas Alarm wiring
         3) Power and control for equipment furnished under these Divisions.
      b. Division 26 Systems:
         1) Automatic Line Voltage Lighting Control Equipment.
   2. Shall be used for:
      a. Systems outlet boxes to accessible ceiling.

B. Cable Trays:
   1. Shall be used for area horizontal ceiling space corridor cabling for the following systems:
      a. Division 27 Systems:
         1) Structured Telecommunications Cabling.
         2) Nurse Call.
         3) Door Entry Intercom.
         4) Intercom.
         5) Broadband Television Distribution.
         6) Structured Telecommunications Cabling.
         7) Public Address.
         8) Digital Broadband Video Distribution.

C. J – Hooks:
   1. Shall be used for separate and independent cabling routing for each of the following systems:
      a. Division 28 Systems:
         1) Fire Alarm.
            a) Except in cases where conduit is required to provide fire rating and/or survivability to meet codes.
         2) Fire Department In-Building Wireless Radio.
            a) Except in cases where conduit is required to provide fire rating and/or survivability to meet codes.
   2. Shall be used for area horizontal ceiling space corridor cabling for the following systems:
      a. Division 23 Systems:
         1) Instrumentation and Control for HVAC.
b. Division 26 Systems:
   1) Lighting Control Equipment.
   2) Lighting Dimming.

c. Division 27 Systems:
   1) Structured Telecommunications Cabling.
   2) Nurse Call.
   3) Door Entry Intercom.
   4) Intercom.
   5) Broadband Television Distribution.
   6) Structured Telecommunications Cabling.
   7) Public Address.
   8) Digital Broadband Video Distribution.
   9) Audio Visual Cabling.

3. Shall be used for:
   a. Equipment room backboard cable management.
   b. Accessible ceiling cabling not installed in other pathways.

3.2 INSTALLATION

A. General:

1. Install all pathways in accordance with EIA/TIA 569A Standards, associated addenda and technical service bulletins and per manufacturer’s requirements.
   a. Install all pathways in a safe, neat, professional, workmanlike manner.
   b. Coordinate size of pathways such that EIA/TIA maximum fill requirements are not exceeded for that raceway size at 40 percent fill maximum.

2. Provide pathways to conceal all cabling in the facility except where specifically indicated otherwise.

3. Coordinate pathway installation such that it is independently supported.

4. Install all pathways parallel and perpendicular to building lines and tight to structure. Install pathways such that multiple cabling runs to the same geographic location will utilize similar pathway routing to destination point.

5. Route cabling pathways to the system equipment room from indicated zone or as shown on Drawings. In general, provide system outlet box pathways to the equipment room on the same floor to a system cabinet or identified equipment.

6. Install pathways to avoid elevator shafts, elevator equipment rooms or any areas that contain or store hazardous materials.

7. Install pathways to avoid sources of electromagnetic interference (EMI) for all pathways.
   a. Maintain 1 foot minimum from fluorescent lighting (ballast).
   b. Maintain 4 foot minimum from all transformers.
   c. Maintain 10 foot minimum from electrical power cabling or distribution panels exceeding 480 volts.
   d. Maintain 1 foot minimum from electrical power cabling.
   e. Maintain 2 inch minimum from electrical power cabling less than 220 volts.
   f. Shorten distances if sufficient EMI isolation is provided and given prior approval by engineer.
8. Avoid routing pathways in areas subject to excessive environmental conditions. Acceptable conditions are:
   a. Temperature Range: 5°C – 50°C.
   b. Relative Humidity Range: 5 percent - 95 percent.

9. Install raceway and equipment identifications per Division 26 Section "Electrical Identification." Label all pathways and associated termination points.
   a. Provide system identifying nameplate centered on main trunk riser boxes, equipment backboards, ground buses, and cabinets (i.e. DATACOM, CCTV, etc.).
   b. Identify fiber optic labeling risers installed in ENT or Innerduct every 10 feet on center "Fiber Optic Cabling."

10. In accessible and non-rated partitions, data/phone device rough-in may be performed with "ring and string" method to consist of a plaster mudring with single gang opening and pull string to above accessible ceiling.

B. Outlet Boxes:
   1. General:
      a. Install systems outlets flush in new wall construction.
      b. Do not install backboxes back-to-back.
         1) Maintain a minimum of 12 inch separation (unless approved otherwise in writing by Engineer).
         2) Maintain a minimum of 24 inch separation in fire-rated walls. Provide approved fire stop materials to maintain the rating of the wall where the minimum separation distances cannot be achieved.
      c. Mount outlets alongside associated power receptacles where applicable.
      d. Mount all outlet boxes vertically, unless otherwise noted.
      e. Install raceway to avoid obstructions in the field such as molding, built-in cabinets, wiring devices, etc.
      f. Install blank coverplates where device type is not installed. Coordinate such locations with the appropriate systems representatives and the Owner.

   2. Renovation:
      a. Utilize installation methods for datacom/systems outlets in the following order as available in renovation areas.
         1) Install systems outlet boxes flush in existing wall. Fish wall as required. Cabling may be run exposed in wall cavity.
         2) Install surface-mounted metal back-box fed with surface mounted metal raceway in renovated areas that cannot be fished and do not require adjacent power receptacles.
         3) Install systems outlets in multi-channel metal surface raceway only where specifically shown on Drawings. Install associated power receptacle adjacent to outlet where required. Provide all mounting bracket hardware and accessories.
            a) Locate vertical section of surface raceway discretely in corner of room for data entrance.
            b) Locate surface raceway outlet rough-in with required spacing as shown on architectural drawing elevations to accommodate knee space at millwork/desks.
4) Cut/trench wall and install conduit stub and backbox for system device cabling.

b. Feed surface raceway in rooms, etc. from conduit extended into corridor space. Cabling may be exposed above accessible corridor/room ceilings. Install conduit in corridors in areas without accessible ceilings.

3. Rework existing surface raceway as required to accommodate new surface raceway and devices.

C. Raceways:

1. Refer to Division 26 Section "Raceways" for basic routing and installation requirements.

a. Refer to Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling" for sleeve requirements.

b. Refer to Division 07 for firestopping.

2. Furnish and install trunk riser raceways, junction boxes, outlet box raceways and outlet boxes as specified and shown on Drawings.

3. Stub trunk riser and extend system outlet box raceways into accessible ceiling space.

4. Provide cap for all conduit stubs and cover for outlet boxes to eliminate debris from entering boxes or conduits. Remove any debris found in conduits or outlet boxes upon cable installation.

5. Where required to provide raceway for outlet boxes, provide a dedicated conduit for cable installation for each Division 27 structured telecommunications cabling system outlet box. These outlet boxes shall not be connected together with conduit between boxes unless otherwise approved in writing by Engineer.

6. Provide minimum outlet box conduit size and conduit sleeve size at 3/4 inch.

   a. Use chart below for minimum conduit size requirements based on maximum 40 percent fill for indicated quantity of cables.

<table>
<thead>
<tr>
<th>Inside Diameter mm</th>
<th>Trade Size</th>
<th>Cable Outside Diameter mm (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.3 (0.13)</td>
<td>4.6 (0.18)</td>
</tr>
<tr>
<td>21</td>
<td>3/4</td>
<td>6</td>
</tr>
<tr>
<td>27</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>35</td>
<td>1-1/4</td>
<td>16</td>
</tr>
<tr>
<td>41</td>
<td>1-1/2</td>
<td>20</td>
</tr>
<tr>
<td>53</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>63</td>
<td>2-1/2</td>
<td>45</td>
</tr>
<tr>
<td>78</td>
<td>3</td>
<td>70</td>
</tr>
<tr>
<td>91</td>
<td>3-1/2</td>
<td></td>
</tr>
<tr>
<td>103</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

7. Mark each conduit end for identification and destination of raceway.

8. Install all raceways such that the cabling manufacturer's minimum bend radius is not exceeded.

9. Furnish and install 200 pound test pullcords in all conduits and as shown on Drawings. Refer to Division 26 Section "Electrical Identification" for labeling requirements.

10. Provide complete conduit systems in areas with non-accessible ceilings for all cable systems.

CONDUIT ROUGH-IN SYSTEMS

260575 - 8
11. Feed multi-channel surface raceway, where shown on Drawings, with one conduit for special outlets and one conduit for each power channel to feed multiple outlets. Refer to ANSI/EIA/TIA 569-A and NFPA 70 for conduit size requirements.

12. Special Optical Fiber and Communication Raceways:
   a. Install fiber optic cabling in Optical Fiber and Communication (innerduct) raceway per Division 26 Section "Raceways." Install Optical Fiber and Communication in cable tray if available, using proper connectors and fittings.

13. Provide conduit segment length at no more than 100 feet with a maximum of two 90 degree bends. Additional junction/pull boxes shall be installed to allow more bends or length of conduit. Refer to EIA/TIA 569A. Coordinate location to nearby cable spool or cable management device.

14. Install telecommunications raceways to within six inches of equipment backboards, data racks and termination units.
   a. Coordinate location and termination to cable management device.

15. Provide an inside bend radius of at least 6 times the internal diameter of the conduit for conduits with internal diameter of 2” or less.

16. Provide an inside bend radius of at least 10 times the internal diameter of the conduit for conduits with internal diameter of more than 2”.

D. J-Hook Installation:
   1. Provide independent J-hook pathways per system where cable tray is not shown, in accessible ceiling space mounted a minimum of 4 and a maximum 5 feet on center. Mount pathway level, tight to structure and allow accessible installation of cabling.
   2. Furnish and install single mounted J-hooks from individual conduits serving outlet boxes mounted 4 feet on center maximum.
   3. Ensure cabling is supported properly and cable does not sag or droop in excess of 8 inches from between supports.

E. Cable Distribution Spools:
   1. Install distribution cable spools (mushrooms) on equipment backboards to allow cable support/routing. Mount spools along edge of boards, 6 inches from each corner and 1 foot on center, minimum.

3.3 RECORD DRAWINGS
   A. Post copy of appropriate systems record drawings in local equipment room as required by Owner’s representatives. Hang set on equipment backboard using proper anchoring techniques.

END OF SECTION 260575
SECTION 260578 – MULTI-SERVICE BOXES AND ASSEMBLIES

PART 1 - GENERAL

1.1 SUMMARY
A. This Section provides requirements and specification criteria for multi-service, multi-outlet boxes, and assemblies. Products specified in this Section include:
   1. Poke Thru Assemblies.
   2. Large Capacity, Multi-Service Poke Thru Assemblies.
   3. Single and Multi-service Floor boxes

1.2 COORDINATION
A. Coordinate multi-service box requirements and their installation in rated construction with Division 07 firestopping requirements to maintain the integrity of the established smoke and fire rating.
B. Coordinate the work of this section with the work required in Divisions 26 and 27.
   1. It is required that the roughing of outlet boxes, floor boxes, poke thru boxes, and their associated raceways, be performed in advance of the finished installation of devices, connectors, ports, etc., and their required wiring and cabling.
C. Coordinate and review the work of this section with the work of other sections and divisions.
D. Verify the exact locations of poke thru and floor boxes and their associated raceways prior to roughing.
E. Refer to Division 26 Section "Wiring Devices" for wiring device specifications.
F. Refer to Division 27 sections for voice/data/communications systems connectors, ports, jacks, etc., device requirements and specifications.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Conditions of Contract, Division 01 Specification Sections, and Division 26 Section "Basic Divisions 26 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data:
   1. Manufacturer’s product data sheet(s) for each product specified, providing dimensional information, product descriptions and performance criteria proving conformance with these specifications.
B. Shop Drawings:
   1. For the following items provide factory supplied fabrication drawings showing plan, views, elevations, sections, specific custom fabrication details and components related to other work.
      a. Multi-service box interiors, indicating elevations, sections, dimensions, barriers, ganging, etc., of the devices, connectors, ports, etc., installed therein.
      b. Detailed layouts of wiring device components, including voice, data and other communications systems jacks, ports, connectors, etc.
2. Raceway Requirements: Provide dimensioned layout drawings of associated raceway feeds, in and out, along with raceway sizes and destinations.

C. Samples:
1. Product Evaluation: Submit complete operating samples, where directed, of products for Owner’s and Engineer’s review.
2. Mock-ups: Provide an operating sample of the specified product, for field installation at the mock-up site.
   a. Deliver sample to Construction Manager for installation at project site. Include costs associated with the samples and their delivery to the project site, in bid.

1.5 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: In addition to items specified in Division 01 Section "Operations and Maintenance Data", provide the following:
   1. Operating and installation instructions for all items provided.
   2. Recommended spare parts list.
   3. Testing and adjustment instructions.
   4. Warranty information.

PART 2 - PRODUCTS

2.1 REGULATORY REQUIREMENTS
A. Listing and Labeling: Items provided under this section shall be designed, fabricated, and tested to Underwriter's Laboratories (UL) Standard 514A and 514C, and shall be so listed and labeled.
B. Federal Specifications: Items provided under this section shall comply with W-C-583b – Conduit Boxes and Outlet Fittings, Floor (for Rigid Conduit).
C. National Electrical Code Compliance: Components and installation shall comply with NFPA 70 "National Electrical Code."
D. NEMA Compliance: Comply with NEMA Standard 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)."

2.2 BOXES AND ASSEMBLIES – GENERAL
A. Boxes and Assemblies: Of indicated types, sizes, and NEMA enclosure classes. Where not indicated, provide units of types, sizes, and classes appropriate for the use and location. Provide all items complete with covers and accessories required for the intended use. Provide gaskets for units in damp or wet locations. Box depths shall exceed depths of installed devices by not less than 1/4 inch.

2.3 MATERIALS AND FINISHES
A. Sheet Steel: Flat-rolled, code-gage, galvanized steel.
B. Fasteners for General Use: Corrosion resistant screws and hardware including cadmium and zinc plated items.
C. Fasteners for Damp or Wet Locations: Stainless steel screws and hardware.
D. Cast Metal for Boxes, Enclosures, and Covers: Cast iron or copper-free aluminum, except as otherwise specified.
2.4 POKE THRU ASSEMBLIES

A. Description: Factory fabricated assembly consisting of:
   1. Electrical outlet box and raceway, to facilitate installation of AC power wiring to assembly, from below.
   2. Service fitting facilitating the installation of wiring devices, ports, connectors, etc.
   3. Firestop barrier and floor closure insert to maintain the integrity of the floor system fire rating.
   4. Raceway(s) to facilitate the installation of low voltage, voice, data, and other communications systems wiring thru the firestop barrier, into the service fitting.
   5. Surface or flush to floor service fittings designed to meet or exceed the UL requirement for scrub water exclusion protection.

B. Size: As required to facilitate the quantity and types of devices specified but shall be not less than 4 inch core hole size. Throat depth and raceway length shall be provided, as required, by floor or slab thickness. Contractor shall verify.

C. Fire Rating: Listed and labeled to maintain the integrity of the specific construction assembly fire rating, but shall be rated not less than 2 hour.

D. Fire Barrier and Closure Plug: Provide to firestop raceway openings and maintain the integrity of the construction assembly fire rating.

E. Wiring Provisions: Provide metal raceway and wiring path(s) to facilitate the field installation of AC wiring to the specified AC wiring devices, and wiring path to facilitate the installation of the specified voice, data, and communications systems wiring and cables.

F. Service Fittings:
   1. Flush-To-Floor Style:
      a. Construction: A combination fitting, consisting of a circular steel wiring device sub plate, regressed below floor surface, to facilitate the installation of the scheduled devices, and finish trim flange and cover.
      b. Scrub water exclusion provisions in accordance with the UL requirement.
      c. Trim Flange: Circular, fabricated from cast aluminum or solid brass, as scheduled, with gasketed beveled edge, for semi-flush integration over carpeted floor surfaces, or flat, flush, gasketed trim for flush integration into tiled, or no finish, floor surfaces.
      e. Finish and Color: Cast Aluminum - polyester powder coat color grey or as specified by Architect.
   2. Furniture Feed Style:
      a. Exposed, trade size raceway knockouts, or cover to raceway adapters, to facilitate wiring connections to “whip” style furniture feed raceways, on a circular flat plate.
      b. Finish and Color: Cast Aluminum - polyester powder coat color grey.
G. Device(s):
   1. Provide in barriered compartments, provided complete with installation hardware and coverplates.
   2. Refer to Drawings for device requirements, quantities, ganging, multi-service requirements, ratings, trade size raceway knockout requirements, etc.

H. Basis of Design:
   1. Hubbell - FRPT Series.

I. Potential Equivalent Manufacturers:
   1. Must be offered to, reviewed by, and accepted by FH prior to use on the project.
      a. FSR - "SmartFit" Series.
      b. Legrand/Wiremold - RC* Series.
      c. Mono Systems - PC* Series.
      d. Thomas and Betts - "Steel City" FPT Series.

2.5 LARGE CAPACITY MULTI SERVICE POKE THRU ASSEMBLIES

A. Description: Factory fabricated assembly consisting of:
   1. Electrical outlet box and raceway, to facilitate installation of AC power wiring to the assembly, from below.
   2. Service fitting facilitating the installation of wiring devices, ports, connectors, etc.
   3. Firestop barrier and floor closure insert to maintain the integrity of the floor system fire rating.
   4. Raceway(s) to facilitate the installation of low voltage, voice, data, and communications systems wiring thru the firestop barrier, into the service fitting.
   5. Flush to floor service fitting designed to meet or exceed the UL requirement for scrub water exclusion protection.

B. Size: As required to facilitate the installation of not less than (2) duplex AC power receptacles, and not less than (4) additional, independent service technology ports, jacks, connectors, etc., and not less than 6-inch nominal inside diameter. The exact quantities and types of devices, ports, jacks, and connectors shall be as scheduled and specified.

C. Fire Rating: Listed and labeled to maintain the integrity of the specific construction assembly fire rating, but shall be rated not less than 2 hour.

D. Fire Barrier and Closure Plug; Provide to firestop raceway openings and maintain the integrity of the construction assembly fire rating.

E. Wiring Provisions: Provide metal raceway and wiring path(s) to facilitate the installation of AC wiring to the specified AC wiring devices, and provisions to allow for field installation of trade size raceway, up to 2 inch, to isolated, barriered compartment(s) to facilitate the installation of the specified service technology wiring and cables.

F. Service Fittings:
   1. Flush-To-Floor Style:
      a. Construction: A combination fitting, consisting of a circular steel wiring device sub plate, regressed below floor surface, to facilitate the installation of the scheduled devices, and finish trim flange and cover.
      b. Scrub water exclusion provisions in accordance with the UL requirement.
c. Trim Flange: Circular, fabricated of die-cast aluminum material, with gasketed beveled edge, for semi-flush integration over carpeted floor surfaces, or flat, flush, gasketed trim for flush integration into tiled, or no finish, floor surfaces.

d. Wiring Device Access Cover: Shall be of die-cast aluminum construction, hinged, opening flat to 180 deg., on its back with spring loaded, sliding, access covers for access to, and cable egress from, concealed, regressed wiring devices, ports, connectors, etc. below.

e. Finish and Color:
   1) Polyester powder coat paint finish - color grey.

G. Device(s):

1. Concealed, installed in regressed barriered metal compartments, below floor surface, provided complete with installation hardware and coverplates.

2. Refer to Drawings for device requirements, ganging, multi-service requirements, ratings, quantities, etc.

H. Basis of Design:

1. Legrand/Wiremold - "Evolution *AT Series.

I. Or the following products fabricated to this Specification:

1. FSR - "SmartFit" Fire Rated Poke Thru Series.


2.6 SINGLE SERVICE AND MULTI-SERVICE FLOOR BOXES

A. Exposed - Device(s) and user plug(s), connector(s), and cord(s) are visible, while in use.

1. Box Construction:

   a. Cast Iron:

   1) Round or rectangular, as scheduled, fabricated from corrosion resistant cast iron material, Class 1 - Watertight and Class 2 - Concrete Tight, suitable for installation in wet placed concrete, with threaded hub style raceway entries, and closure plugs for hubs not used.

   2) Type 1 - Fully adjustable, with adjustable leveling feet for rough floor elevation adjustment, prior to floor material installation, and adjustable, round or rectangular, cast aluminum or brass, as scheduled, riser collar for finished floor leveling, after floor material installation.

   3) Provide with closure cap to prevent floor material entry into box during installation process.

   4) Provide single gang, single service, or multi-gang multi-service barriered boxes, to facilitate the installation of device(s) and service fitting(s) specified.

2. Service Fittings and Covers:

   a. Flush To Floor Style:

   1) Round or rectangular, fabricated from aluminum, brass, or non-metallic material, as scheduled, designed for flush fit to finished floor elevation, over matching box riser collar material and shape.

   2) Scrub water exclusion provisions in accordance with the UL requirement.

   3) Provide complete with integral, or separately installed, raised tile flange accessory, to allow for flush installation to tiled floor finishes, or carpet flange accessory, to allow for semi-flush installation to carpeted floor finishes.
4) Finish shall be clear lacquer over the specified solid metal material.
5) Provide with flip top type access cover.

b. Furniture Feed Style:
   1) Exposed, trade size raceway knockouts, to facilitate wiring connections to "whip" style furniture feed raceways, on a circular or rectangular flat plate, as scheduled.
   2) Finish and Color: Solid aluminum or brass-polyester powder coat grey, natural or brushed aluminum or other color, as scheduled.

c. Surface "Tombstone" Style:
   1) Rectilinear, metallic, electrical box style fitting, designed for surface installation over flush floor box.
   2) With internal barrier, separating the fitting into 2 separate wiring and connection compartments.
   3) Provide complete with coverplates designed for field installation over the specified and scheduled wiring devices and connectors, or blank knockout style covers for furniture feed applications, as scheduled.

3. Device(s):
   a. Refer to Drawings for device requirements, quantities, ganging, multi-service requirements, raceway requirements, etc.

4. Accessories:
   a. Concrete pour pan.

5. Basis of Design:

6. Acceptable Equivalent Manufacturers:
   a. Legrand/Wiremold.
   b. Raco.
   c. Steel City/Thomas and Betts.

B. Concealed - Device(s) and user plug(s) or connector(s) are not visible, while in use.
   1. Box Construction:
      a. Cast Iron:
         1) Fabricated from corrosion resistant cast iron material, Class 1 - Watertight and Class 2 Concrete Tight, suitable for installation in wet placed concrete, provided with threaded hub style raceway entries as required, and closure plugs for hubs not used.
         2) Type 1 - Fully adjustable, with mechanical feet for rough floor elevation adjustment, prior to floor material installation, and adjustable, rectangular, riser collar for finished floor leveling, after floor material installation.
         3) Provide with closure cap to prevent floor material entry into box during installation process.
         4) Provide single gang, single service, or multi-gang multi-service barriered boxes, to facilitate the installation of device(s) and service fitting(s) specified.
2. **Service Fittings and Covers:**
   a. Rectangular, fabricated from metallic and non-metallic materials, designed for flush fit to finished floor elevation, over matching box riser collar material and shape.
   b. Scrub water exclusion provisions in accordance with the UL requirement
   c. Provide complete with integral, or separately installed, raised tile flange accessory, to allow for flush installation to tiled floor finishes, or carpet flange accessory, to allow for semi-flush installation to carpeted floor finishes.
   d. Provide with a single, hinged, access door assembly, providing full access to concealed devices below, and rocker or flip style cable vent(s) to allow cables and cords to exit box with access door closed.
      1) Access door assembly shall provide a regress, to allow for field installation of matching carpet or tile floor material into the regress.
   e. Finish shall be:

3. **Device(s):**
   a. Regressed, installed in concealed barriered metal compartments, below floor surface, provided complete with installation hardware and coverplates.
   b. Refer to Drawings for device requirements, quantities, ganging, multi-service requirements, raceway requirements, etc.

4. **Accessories:**
   a. Concrete pour pan.

5. **Basis of Design:**
   a. Hubbell – 3SFBC Series.

6. **Acceptable Equivalent Manufacturers:**
   a. Legrand/Wiremold.
   b. Steel City/Thomas and Betts

2.7 **CONCRETE POUR PANS**
   A. Sheet metal pans specifically designed and fabricated for installation at floor box locations where floor boxes are installed within concrete slabs, poured at grade.
   B. Provides a flat surface for floor box leveling feet height adjustment allowing concrete to flow underneath floor box.
   C. Fabricated from galvanized sheet steel, formed into square shape with flat bottom, raised angular sides, with mitered corners, forming a pan not less than 2 inches deep.
      1. Provide pan size based on floor box dimensions.
      2. Provide pan depth based on depth of floor box, thickness of concrete slab, and specified depth of concrete required to flow under floor box.
   D. **Basis of Design:**
      1. FSR - FL-GRD Series.
      2. Or equivalent, provided by floor box manufacturer.
PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Install items where indicated and where required to suit code requirements and installation conditions.

B. Maintain the environmental rating of the enclosures. Install only listed or recognized raceways and fittings providing the same rating and integrity as the enclosure, in compliance with the installation instructions of the device.
   1. Cap unused knockout holes where blanks have been removed and plug unused raceway hubs.
   2. Use listed connectors to maintain raceway to enclosure grounding and bonding integrity. Cut through paint as applicable. Cutting slots shall not be acceptable for conduit entries into enclosures.

C. Support and fasten items securely in accordance with Division 26 Section "Hangers and Supports."
   1. Fasten boxes to or support from building structure. Do not support boxes by raceways.

D. Provide to meet NEC volume requirements, but in no case smaller than sizes indicated.

E. Remove sharp edges where they may come in contact with wiring or personnel.

F. Refinish and paint enclosures in field due to any field modifications.

G. Provide box sizes as required by the National Electrical Code with oversize boxes as shown on Drawings. Obtain special backboxes with associated equipment when available.

H. Provide where required for outlet facility and rough-in requirements. Securely support from building construction with listed and approved rods, hangers, brackets, supports, etc., independent of raceways. Provide backing extension for all steel device boxes in stud walls or support box on two opposite sides such that cover plate and drywall is not stressed to hold box in position.

I. Install concealed, flush to finished wall, floor, or ceiling construction materials, except where otherwise shown or specified as surface installed.

J. Maintain accessibility to all boxes.

K. Provide so no part of box is visible, and is completely covered by service covers, device fittings, trims, etc.

L. Do not install boxes back to back at the same relative location. Install boxes offset from one another, to maintain integrity of fire and sound rated construction. Drawings are diagrammatic only. Those installations not approved shall be corrected at no cost to the Owner.

M. Install boxes so that access covers and coverplates do not span across different building finishes.

N. Where two or more devices are shown or otherwise specified to be installed at the same relative location, and at the same elevation, install those devices in a common multi-gang barriered box as appropriate for the device types.
   1. Maintain box and wiring separations per NEC. Pullbox barriers will not be acceptable except for special cases brought to the engineer's attention prior to installation.

O. Where two or more devices are shown, or otherwise specified to be installed at the same location, but at different elevations, rough boxes vertically on common center line.
P. Provide barriers to segregate AC voltages, segregate normal and emergency distribution system branch circuit wiring, and to segregate AC system wiring from voice/data/communications systems wiring per NEC.

Q. Set floor boxes and service fittings level at height to match trim with flooring type.

3.2 APPLICATIONS
A. Provide electrical identification per Division 26 Section "Electrical Identification."

B. Boxes and Fittings: Install concealed, unless noted otherwise, with associated covers and fittings of materials and NEMA rating, as specified, suitable for each installed location, and in conformance with the following requirements.
   1. Interior Dry Locations: Sheet steel, NEMA 1.
   2. Slab on Grade Locations: Cast iron

C. Galvanized steel boxes may be installed in:
   1. Concealed interior locations.

D. Provide the appropriate service fitting cover style and floor matching trim and accessories to suit floor construction.

3.3 INSTALLATION – POKE THRU ASSEMBLIES
A. Verify exact locations with Architect prior to roughing.

B. Verify required core drill diameter with manufacturer. Install manufacturers supplied blank-off plates until wiring and activation of devices.

C. Install per manufacturer's instructions.

D. Verify floor finish with Architect and provide the appropriate trim flange to match the floor construction.
   1. Provide beveled, over-carpet style trim ring for assemblies installed in floors that will receive a carpeted type of floor finish. Verify depth of carpeting prior to setting assembly.
   2. Provide square edge, flush style trim ring for assemblies installed in floors that will receive a tiled, terrazzo, wooden, or similar non-carpeted type of floor finish. Verify depth of finish floor material prior to setting assembly.

3.4 INSTALLATION – FLOOR BOXES
A. Verify exact locations prior to roughing.

B. Verify floor finishes and provide the appropriate trims to match floor finish materials.

C. Provide the following, for floor box installations in concrete, at grade:
   1. Excavate sub-surface materials directly below floor box locations to allow concrete pour to flow underneath floor box.
   2. Provide concrete pour pan under box and adjust box leveling feet to allow concrete to flow between floor box and pan, to a thickness not less than the overall depth of the floor box.
      a. For extra deep floor boxes, where factory supplied leveling feet cannot provide the above specified concrete thickness to flow under floor box, provide concrete bricks under floor box to allow the specified concrete thickness to flow.
3.5 IDENTIFICATION
   A. Per Division 26 Section "Electrical Identification."

3.6 GROUNDING AND BONDING
   A. Electrically bond metallic cabinets, boxes, enclosures and their associated raceways to the
      building grounding and system. Where wiring to box or cabinet includes a grounding and bonding
      conductor, provide a terminal in the interior of the cabinet, box or enclosure and connect
      conductor.

3.7 CLEANING AND FINISH REPAIR
   A. Upon completion of installation, inspect components. Remove burrs, dirt and construction debris
      and repair damaged finish including chips, scratches, abrasions and weld marks.
   B. Galvanized Finishes: Repair damage using a zinc-rich paint recommended by the equipment
      manufacturer.
   C. Painted Finishes: Repair damage using matching corrosion inhibiting touch-up coating.

END OF SECTION 260578
SECTION 260800 – COMMISSIONING of ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. The purpose of this section is to specify the Division 26 responsibilities and participation in the commissioning process.

B. Work under this contract shall conform to requirements of Division 01, General Requirements, Conditions of the Contract and Supplementary Conditions. This specification covers commissioning of Electrical systems which are part of this project.

C. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.

1.2 REFERENCE

A. Applicable provisions of Division 1 govern work under this section.

B. Specific performance requirements are given in the following sections of these specifications:

1. Division 01 Section "Project Management and Coordination"
2. Division 01 Section "Submittal Procedures"
3. Division 01 Section “Sustainability Certification Project Requirements”
4. Division 01 Section "Starting and Adjusting"
5. Division 01 Section "Closeout Procedures"
6. Division 01 Section “Closeout Submittals”
7. Division 01 Section "Demonstration and Training"
8. Division 01 Section “General Commissioning Requirements”
9. Division 20 Section “Functional Performance Testing Common Work Results, Division 21 – 28”
10. Division 26 Section "Basic Electrical Requirements"
11. Division 26 Section 'Electrical Inspections and Testing"

C. Sustainable Design Intent: Comply with project requirements to meet the applicable commissioning prerequisites and credits pursued for the Sustainability/Sustainable Green Building Rating System, of the US Green Building Council.


1.3 DEFINITIONS

A. Commissioning (Cx): The process of ensuring that systems are designed, installed, functionally tested and performing in conformity with Owners Project Requirements (OPR) the design intent (Basis of Design BoD)) and that the building operator has received complete equipment and systems documentation and training.

B. Commissioning Provider (CxP): The entity identified to lead, monitor, coordinate and report on project commissioning activities.
C. Commissioning Plan: A detailed plan of the organization, schedule, allocation of resources, procedures and documentation requirements of the commissioning process.

D. Construction Verification (CV): A quality control verification process performed by the installer as building assembles, components, equipment and systems are being installed which documents that the materials, installation procedures, interfaces with other trades, start-up, testing and operation are correct, complete and in compliance with contract documents and manufacturer’s recommendations and are ready for functional performance testing.

E. Functional Performance Tests (FPT): Contractor testing of installed building assembles, components, equipment, systems and interfaces which confirms correct performance through all operating modes and compliance with contract documents and manufacturer’s recommendations.

F. Commissioning Report: A document that records the activities and results of the commissioning process.

1.4 COORDINATION

A. Commissioning Team: The members of the commissioning team consist of the Commissioning Provider (CxP), the Owner’s Project Manager (OPM), the Construction Manager or General Contractor (CM or GC), the design Architect and Engineers (A/E), the Mechanical Contractor (MC), the Electrical Contractor (EC), the Testing, Adjusting, and Balancing contractor (TAB), the Controls Contractor (CC), the Communications and Technology Contractor (CTC), the Owner’s maintenance staff, and any other installing subcontractors or suppliers of equipment.

B. Management: The general contractor that is awarded the project shall not include the cost of the Commissioning Provider in their price. The general contractor (and their sub-contractors) shall include cost for their involvement in the commissioning process as described in this section and other related commissioning sections, including completion of construction verification checklists, demonstration of installed equipment to the commissioning team members during the functional performance testing portion of the project.

C. Scheduling: The CM/GC shall integrate all commissioning activities into the master construction schedule. A timeline determined by the commissioning agent will be dedicated for system commissioning. The MEP Contractors shall coordinate their commissioning schedule needs with CM prior to the start of construction to ensure inclusion into the overall construction schedule. The CxP will work with the OPM and CM/GC to schedule commissioning activities. All parties will address scheduling issues in a timely manner in order to expedite the commissioning process.

D. Tracking Contractor Required Testing: Each contractor is responsible for completing various tests per their associated specifications. Each contractor will forward a list of their associated tests to the CxP, who will generate an overall list for tracking purposes.

1.5 COMMISSIONING PROCESS

A. The following activities describe the commissioning tasks and the general order in which they occur. The CxP coordinates all activities.

1. Scoping Meeting: All members of the design and construction team that will be involved in the commissioning process meet and agree on the scope of work, tasks, schedules, deliverables, and responsibilities for implementation of the Commissioning Plan.

2. Commissioning Plan: The Commissioning Plan developed by the CxP provides guidance in the execution of the commissioning process. The Specifications take precedence over the Commissioning Plan.
3. Submittals: Contractor submittals, including detailed start-up procedures, applicable to systems being commissioned is submitted to the CxP to be reviewed concurrent with the A/E’s review. The CxP will review contractor submittals for compliance with OPR and BoD.

4. Site Visits: Commissioning is a team effort requiring the cooperation of all parties. Contractors are to proactively carry out their commissioning responsibilities and are to assist the CxP during site visits in performing commissioning tasks. This includes providing access to and demonstrating the installation, operation and testing of commissioned systems; responding to CxP requests for information; carrying out proactive and corrective actions; and accurate reporting on system status and conditions.

5. Start-Up/Construction Verification Checklists: The CxP works with the Subcontractors to develop startup plans and documentation formats, including providing the Subcontractors with construction verification checklists to be completed prior to the acceptance testing process.

6. Functional Performance Testing: The CxP develops specific equipment and system functional performance test procedures. The Subcontractors review the procedures. The procedures are executed by the Subcontractors, under the direction of, and documented by the CxP.

7. Deficiencies and Resolution: The CxP documents items of non-compliance in materials, installation or operation in an Issues Log. The items are corrected at the Sub’s expense and the equipment or systems are retested. Each contractor is responsible for completing action items in a timely manner that are noted in the Issues Log as their responsibility. Timely response and successful completion are a requirement to avoid withholding of payment. The CM/GC will be responsible for any cost associated with the CxP for retesting.

8. Operations and Maintenance Documentation: The CxP reviews the Operation and Maintenance documentation provided by the Subcontractors for completeness.

9. Training: The CxP reviews the training provided by the Subcontractors and verifies that it is completed.

10. Seasonal Testing: Deferred or seasonal testing is conducted, as required.

11. Warranty Review: The CxP will review status of warranty and building performance issues with the OPM, A/E, CM/GC roughly 10 months after occupancy.

1.6 RESPONSIBILITIES

A. The responsibilities of various parties in the commissioning process are provided in this section. Note that the services for the Owner’s Project Manager, Design Team, and Commissioning Provider are not included in this contract. The Contractor is not responsible for providing their services. Their responsibilities are listed here to clarify the commissioning process.

B. Commissioning Provider (CxP): The CxP is not responsible for design concept, design criteria, code compliance, general construction scheduling, cost estimating, or construction management. The CxP may assist with problem-solving deficiencies, but ultimately that responsibility resides with the General Contractor and the A/E. The primary role of the CxP is to develop and coordinate the execution of a testing plan to verify and document that systems are functioning in accordance with the design intent and the Construction Documents.

1. Construction and Acceptance Phase:
   a. Coordinates and directs all commissioning activities. Work with the CM/GC and OPM to confirm that commissioning activities are scheduled.
   b. Maintain an up-to-date Commissioning Plan.
   c. Plan and conduct the commissioning scoping meeting.
d. Request and review additional information required to perform commissioning tasks, including Operation and Maintenance materials, contractor start-up and checkout procedures, and sequences of operation.

e. Review Contractor submittals applicable to commissioned systems.

f. Assist Subcontractors with the development of start-up and checkout plans.

g. Write and distribute construction verification checklists to be completed by the responsible Subcontractor.

h. Perform site visits, as necessary, to observe component and system installations. Attend construction job-site meetings, as necessary, to monitor construction and commissioning progress.

i. Review completed construction verification checklist and start-up reports.

j. Assist with coordination of start-up requirements with TAB requirements.

k. Write functional performance test procedures for equipment and systems.

l. Coordinate, witness, and document functional performance tests completed by installing contractors. Coordinate retesting as necessary until satisfactory performance is verified.

m. Maintain a master deficiency and resolution record. Provide the OPM with written progress reports and test results with recommended actions.

n. Review the training proposed by the contractors for the Owner's operating personnel.

o. Review the Operation and Maintenance manuals.

p. Prepare a final commissioning report.

2. Warranty Period:

a. Coordinate and supervise required seasonal or deferred testing and deficiency corrections.

b. Assist in the development of a preventative maintenance plan and review as-built documentation.

C. Design Team (A/E):

1. Construction and Acceptance Phase:

a. Attend commissioning scoping meeting and additional meetings, as necessary.

b. Provide design intent and sequence of operation documentation as required by the CxP.

c. Assist in resolution of system deficiencies identified during commissioning.

d. Review and approve the operations and maintenance manuals.

2. Warranty Period:

a. Assist in resolution of system deficiencies identified during warranty period commissioning.

b. Attend the end-of-warranty review walkthrough to assist in identifying issues requiring resolution and the action plan to do so.

D. Owner’s Project Manager (OPM):

1. Construction and Acceptance Phase:

a. Manage the contract of the CxP.

b. Attend commissioning scoping meeting and additional meetings, as necessary.

c. Arrange for facility operating and maintenance personnel to participate in commissioning activities and training sessions.

d. Provide final approval for the completion of the commissioning work.

COMMISSIONING of ELECTRICAL SYSTEMS

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2. Warranty Period:
   a. Ensure that any seasonal or deferred testing and any deficiency issues are addressed.
   b. Attend the end-of-warranty review.

E. General Contractor or Construction Manager (CM or GC):
1. Construction and Acceptance Phase:
   a. Facilitate the coordination of the commissioning work by the CxP.
   b. Attend commissioning scoping meeting and additional meetings, as necessary.
   c. Furnish copies of construction documents, addenda, change orders and approved submittals and shop drawings related to commissioned equipment to the CxP.
   d. Confirm that Subcontractors execute their quality assurance and commissioning responsibilities according to the Specifications and Commissioning Plan.
   e. Ensure CxP access to observe and witness equipment system installation and operation.
   f. Coordinate the training of Owner personnel, according to the Specifications.
   g. Prepare Operation and Maintenance manuals, according to the Specifications, including updating original sequences of operation to as-built conditions.
   h. Attend regularly scheduled commissioning meetings.

2. Warranty Period:
   a. Confirm that Subcontractors execute required seasonal or deferred functional performance testing.
   b. Confirm that Subcontractors correct deficiencies and make necessary adjustments to Operation and Maintenance manuals and as-built drawings for issues identified during the warranty period.
   c. Attend the end-of-warranty review.

F. Equipment Suppliers:
1. Provide requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in effect.
2. Provide information requested by CxP regarding equipment sequence of operation and testing procedures.
3. Assist in equipment testing and training per agreements with Subcontractors.

G. Mechanical, Electrical, Plumbing, Controls, TAB and other Sub-Contractors:
1. Installing subcontractors shall fill out construction verification checklists generated by the CxP.
2. The sub-contractor responsible for the startup and operational checkout of each commissioned system shall participate in functional performance testing and execute the test plans generated by the CxP.
3. Attend regularly scheduled commissioning meetings.
4. Ensure CxP access to observe and witness equipment system installation and operation.
5. Submit required Contractor quality assurance test reports to Architect and Commissioning Provider for review.
6. Submit completed start-up reports for commissioned equipment signed by the factory-trained and authorized representatives performing the associated work.
7. Submit Testing and Balancing plan for review and completed TAB report to Architect and Commissioning Provider for review.
8. Submit completed System Readiness Checklists, with completed startup sheets attached, to Commissioning Provider. System functional performance testing shall not commence until the system is documented as ready for testing.
9. Submit operation and maintenance (O&M) manuals for systems being commissioned to Architect and Commissioning Provider for review.
10. Provide training for the Owner’s facility staff for regular operations, maintenance, and troubleshooting.
11. Refer to applicable quality assurance and commissioning sections as noted in Section 1.2 for additional responsibilities.

1.7 COMMISSIONING SCOPE
A. The following checked equipment shall be commissioned for this project.
B. Existing downstream devices and terminal units of new primary equipment shall be included in the commissioning scope.
C. FPT sample is 100% unless noted otherwise.
D. Integrated systems interactions between HVAC, Electrical, etc. shall be tested. Reference Division 20 Section “Functional Performance Testing Common Work Results, Division 21 – 28”

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PART 2 - PRODUCTS

2.1 TEST EQUIPMENT
A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested. Equipment to be calibrated within the past year and in accordance with the manufacturer’s recommendations.
B. Contractors to provide the electronic means (equipment) required to enter construction verification data from on site if the Commissioning Provider utilizes a web-based program.
C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed.

D. All testing equipment shall be of sufficient quality and accuracy to test or measure system performance as required by the specifications.

E. Datalogging equipment or software required to test equipment provided by the CxP shall not become the property of the CM/GC or Owner.

PART 3 - EXECUTION

3.1 MEETINGS

A. Pre-Construction Scoping Meeting: The CxP will schedule, plan and conduct a pre-construction scoping meeting with the entire commissioning team in attendance. The CM/GC will ensure all relevant Subcontractors attend. The CxP will present an overview of the project’s commissioning process and the commissioning team members will be identified and their responsibilities reviewed.

B. Miscellaneous Meetings: Other meetings will be planned and conducted by the CxP as construction progresses. Each contractor is required to attend all meetings related to commissioning (pre-construction, construction progress, commissioning meetings, etc.) and to have personnel requested by CxP in attendance to facilitate quality control and coordinate commissioning efforts. Contractors are to provide a review of project progress, a report on the status of issues, commissioning tasks and scheduling for future commissioning tasks.

C. Warranty Review Meeting: Within 10 months of substantial completion and prior to completion of the warranty period, CxP will coordinate and facilitate a review meeting. The intent of the meeting will be to review the project design, construction, turnover, operation and warranty issues. Contractor is required to have key project personnel in attendance and participating in the review for the purposes of making future project delivery improvements.

D. The CxP will distribute meeting minutes to all parties.

3.2 REPORTING

A. The CM/GC shall include the CxP on all OAC construction meeting minutes distribution.

B. The CM/GC shall include the CxP on all Requests For Information (RFI) and Change Order Requests (COR) related to commissioned equipment and systems.

C. The CxP will regularly communicate with all members of the commissioning team, apprising them of commissioning progress and scheduling changes through memos, progress reports, etc.

D. The CM/GC will respond to the CxP’s deficiency record with resolution updates.

E. The CM/GC will provide documentation as required for the CxP to compile a final Commissioning Report which summarizes all of the tasks, findings, and documentation of the commissioning process. The report addresses the actual performance of the building systems in reference to the design intent and contract documents. The report includes a summary of commissioning activities, contact and warranty information, completed construction verification checklists, functional performance testing records, diagnostic monitoring results, identified deficiencies, recommendations for warranty review meeting and ongoing commissioning effort.
3.3 SUBMITTALS

A. Refer to Division 01 General Requirements and Section "Submittals" and relevant Division sections for requirements.

B. The CM/GC shall provide the CxP submittals related to the commissioned equipment to review for conformance to the Construction Documents as it relates to the commissioning process. The review is intended primarily to aid in the development of functional performance test procedures.

C. The CM/GC shall respond to request for additional information from the CxP as needed to facilitate the commissioning process.

D. The CxP may request additional design and operations narrative from the design team and Controls Contractor regarding sequences of operations.

3.4 START-UP and CONSTRUCTION VERIFICATION CHECKLISTS

The following procedures apply to all equipment to be commissioned, according to Section 1.7, Commissioning Scope.

A. Start-Up Plans:

1. The responsible contractors shall develop detailed start-up plans for all equipment to be commissioned. The CxP will review start-up plans to confirm that there is written documentation that each of the manufacturer-recommended procedures is completed.
2. Subcontractors and equipment suppliers schedule startup and checkout with the OPM, CM/GC and CxP.
3. All work to be installed in accordance with the manufacturer's instructions. The subcontractors and vendors execute manufacturer installation procedures and start-up documentation. A copy of completed start-up checklists shall be provided to the CxP.
4. The start-up plans and documentation may be provided to the OPM and A/E for review.

B. Construction Verification Checklists:

1. The construction verification checklists are a formalized means to provide individual workers the criteria for a successful installation, adherence to the construction documents and to easily track construction progress.
2. Each assembly, component, equipment, system and interface to be commissioned shall be verified by the installer at the site while work is underway and documented on the construction verification checklists. The contractor is responsible for successfully completing installations, documenting this on the construction verification checklist forms and correcting all deficiencies.
3. Construction verification checklists are developed by the CxP for all major equipment and systems being commissioned. The checklist documents all equipment components are installed and functional and confirms the as-built status of the equipment or system. These checklists also assist in confirming that the systems are complete and operational, so that the functional performance testing can be scheduled.
4. Construction verification checklists will be electronic and available via a web-based program. It is the contractor's responsibility to have an electronic means of entering this data from on site.
5. Construction verification checklists shall be filled out and signed by the installing subcontractor for each piece of equipment. Only individuals who have completed or witnessed the line item task shall complete and sign the checklists.
6. Contractor shall periodically review the construction verification checklist schedule with the CxP allowing advance notice of activities of 5 business days so that the CxP may witness as deemed necessary.
7. Calibration of all sensors shall be included as part of the construction verification checklists performed by the Contractors.

C. Deficiencies, Non-Conformance, and Approval in Checklists and Startup:
1. The Subcontractors shall clearly list any items of the start-up and construction verification procedures not successfully completed at the bottom of the form or on an attached sheet. The procedures form and any outstanding deficiencies are provided to the CxP within two days of test completion.
2. The CxP will verify the accuracy of the completed start-up forms and construction checklists compared with actual field installation and recommends approval to the OPM.
3. If CxP identifies more than a 10% discrepancy rate during confirmation of construction verification checklists, the contractor shall correct all deficiencies and revalidate all items covered by that checklist and resubmit new checklists.
4. The cost of reconfirmation of construction verification checklists due to equipment or construction deficiencies is the responsibility of the contractor and subject to deductive change order at owner's/construction manager’s discretion. Correction of deficiencies and revalidation are the responsibility of the contractor and are not subject to time extensions or delay claims.

3.5 FUNCTIONAL PERFORMANCE TESTING
A. Functional performance testing for each system in the commissioning scope shall be executed by the sub-contractor responsible for the startup and operational checkout of the system.
B. The following procedures apply to all equipment to be commissioned, according to Section 1.7, Commissioning Scope. This sub-section applies to all commissioning functional performance testing for all divisions.
C. Objectives and Scope: The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Construction Documents. Functional performance testing comprises a full range of tests to verify that all components, equipment, systems, and interfaces between systems operate correctly. This includes all operating modes, interlocks, control sequences, and responses to emergency conditions. All verification procedures are directed, witnessed, and documented by the CxP.
D. Development of Test Procedures: The CxP develops specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Prior to execution, the CxP provides the test procedures to the Sub(s) who review the tests for feasibility, safety, equipment and warranty protection. The CxP may submit the tests to the A/E team for review.
E. Test Methods:
1. Functional performance testing and verification may be achieved by direct manipulation of system inputs (i.e. heating or cooling sensors), manipulation of system inputs with the building automation system (i.e. software override of sensor inputs), trend logs of system inputs and outputs using the building automation system, or short-term monitoring of system inputs and outputs using stand alone data loggers. A combination of methods may be required to completely test the complete sequence of operations. The CxP determines which method, or combination, is most appropriate.
2. **Setup**: Each test procedure is performed under conditions that simulate normal operating conditions as closely as possible. The Sub executing the test provides all necessary system modifications to produce the specified conditions (flows, pressures, temperatures, etc) necessary to execute the test. At completion of the test, the Sub returns all affected building equipment and systems to their pre-test conditions.

3. **Sampling**: Multiple identical pieces of non-life-safety or non-critical equipment may be functionally tested using a sampling strategy. The CxP shall establish sampling protocol with approval of the OPM, and at the time of testing select sample test locations for identical pieces of equipment. Where simulation of conditions or altering of setpoints or values is required to achieve an operating or failure mode for testing, the contractor must receive CxP approval. If, after three attempts at testing the specified sample percentage, failures are still present, then all remaining units are tested at the contractors’ expense.

F. **Coordination and Scheduling**: Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures.

G. **Contractor**: shall coordinate functional performance testing with CxP, the construction manager, and the owner and notify them 5 business days prior to testing so that they may witness and document the test results. All contractors involved with specific assemblies, components, equipment, systems and interfaces shall have qualified installers and technicians present at the same time working together to perform testing and demonstrate correct performance through all operating and failure modes and compliance with contract documents and manufacturer’s recommendations.

H. **With Owner and CM oversight**, the CxP is responsible for witnessing functional performance testing and recording the results and deficiencies. The following sequential priorities are followed:

1. Equipment is not "temporarily" started (for heating or cooling), until pre-start checklist items and all manufacturers’ pre-start procedures are completed and moisture, dust and other environmental and building integrity issues have been addressed.
2. Functional performance testing does not begin until construction verification, start-up, controls verification of installation (all sequences and points), and TAB is completed for a given system.
3. The controls system and equipment it controls are not functionally tested until all points have been calibrated and construction verification checklists are completed.

I. Contractors are responsible for completing and coordinating their work with all trades prior to testing, preplanning testing procedures, ensuring necessary staff and resources are on hand and expediting testing. This includes, but not limited to, completing testing and balancing by the HVAC contractor required for successful functional performance testing, pre-testing of the systems (completing FPT) prior to testing with CxP. Pre-testing will include submission of trending per the request of CxP. Failure to complete or coordinate work, preplan or have staff and resources available to carry out testing will result in retesting.

J. **Problem Solving**: The CxP may recommend solutions to deficiencies identified during functional testing. However, the burden of responsibility to solve, correct and retest deficiencies is with the CM/GC, Subcontractors and A/E.

3.6 **EMERGENCY GENERATOR**

A. **Parties Responsible to Execute Functional Test**

1. Vendor Support Representative
2. Electrical Contractor
3. CxP: To witness and document testing
B. Integral Components or Related Equipment Being Tested: Prefunctional Test Complete?
   1. Generator Motor
   2. Generator Cooling System
   3. Generator Fuel System
   4. Phase Rotation

C. Prerequisites:
   1. The applicable prerequisite checklist items listed in the Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

<table>
<thead>
<tr>
<th>Function/Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
</tr>
<tr>
<td>1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, shutdown, remote annunciation. Test functionality of this piece of equipment or system in all control strategies or interlocks with which it is associated.</td>
</tr>
<tr>
<td>2. Stimulate power outage and subsequent automatic transfer switch operation(s)</td>
</tr>
<tr>
<td>3. Generator start capability upon signal from ATS upon loss of utility power</td>
</tr>
<tr>
<td>4. Check all alarms and annunciators local and remote and remote</td>
</tr>
<tr>
<td>5. Demonstrate interior of enclosure operational, i.e., lighting, battery chargers, etc.</td>
</tr>
<tr>
<td>6. Demonstrate proper functioning of governor and regulator</td>
</tr>
<tr>
<td>7. Verify operation of all mechanical equipment elevators and fire pump from generator power and restart upon re-energizing normal power.</td>
</tr>
</tbody>
</table>

D. Functions/Modes Required To Be Tested, Test Methods:
   1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

E. Acceptance Criteria (referenced by function or mode ID):
   1. For the conditions, sequences and modes tested, the generator, integral components and related equipment respond to varying loads and changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

END OF EMERGENCY GENERATOR

3.7 EMERGENCY LIGHTING

A. Parties Responsible to Execute Functional Test:
1. Electrical Contractor
2. CxP: To witness and document testing

B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.

1. Emergency Lighting Fixtures
2. Emergency Bypass Relays

C. Prerequisites:

1. The applicable prerequisite checklist items listed in Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods:

1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

<table>
<thead>
<tr>
<th>Function / Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
</tr>
<tr>
<td>1. Test all manual controls individually.</td>
</tr>
<tr>
<td>2. Demonstrate all automatic functions using manual control overrides.</td>
</tr>
<tr>
<td>3. Demonstrate all interlocking functions, i.e., security/fire alarm.</td>
</tr>
</tbody>
</table>

E. Acceptance Criteria

1. Acceptance is achieved when all functions of the specified system have been demonstrated.

F. Sample strategy for identical units: No sampling, test all.

END OF EMERGENCY LIGHTING

3.8 SHORT CIRCUIT TRIP

A. Parties Responsible to Execute Functional Test:

1. Electrical Contractor
2. CxP: To witness and document testing

B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.

1. Breaker trip settings for all adjustable trip type breakers

C. Prerequisites:

1. The applicable prerequisite checklist items listed in Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.
D. Functions/Modes Required To Be Tested, Test Methods:
   1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

<table>
<thead>
<tr>
<th>Function/Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
</tr>
<tr>
<td>1. Review breaker settings per the short circuit protection study.</td>
</tr>
</tbody>
</table>

E. Acceptance Criteria (referenced by function or mode ID):
   1. System is in compliance when trip settings are observed to be coordinated with report recommendations.

F. Sampling strategy for identical units: No sampling, test all.

END OF SHORT CIRCUIT TRIP

3.9 LIGHTING CONTROL SYSTEM

A. Parties Responsible to Execute Functional Test:
   1. Vendor Support Representative
   2. Electrical Contractor
   3. CxP: To witness and document testing

B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.
   1. Head end system (PC)
   2. Relay panels
   3. Occupancy sensors
   4. Low voltage switches
   5. Daylight switches and override
   6. System software

C. Prerequisites:
   1. The applicable prerequisite checklist items listed in Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods:
   1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

<table>
<thead>
<tr>
<th>Function/Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
</tr>
<tr>
<td>1. Demonstrate all functions of the lighting control/low voltage switching system and head end equipment.</td>
</tr>
</tbody>
</table>
E. Acceptance Criteria (referenced by function or mode ID):
   1. Acceptance is achieved when all lighting functions are successfully demonstrated.

F. Sampling Strategy for Identical Units: No sampling, test all.

END OF LIGHTING CONTROL SYSTEM

3.10 AUTOMATIC TRANSFER SWITCH(ES)

A. Parties Responsible to Execute Functional Test:
   1. Vendor Support Representative
   2. Electrical Contractor
   3. Building Inspector
   4. CxP: To witness and document testing
   5. Balancing Contractor to verify flows

B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.
   1. Manual and automatic operation
   2. Function annunciation

C. Prerequisites:
   1. The applicable prerequisite checklist items listed in Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods:
   1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specification.

<table>
<thead>
<tr>
<th>Function/Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
</tr>
<tr>
<td>1. Verify installation of switch.</td>
</tr>
<tr>
<td>2. Demonstrate compliance with electrical sequence of operation.</td>
</tr>
</tbody>
</table>

E. Acceptance Criteria
   1. Acceptance is achieved when all functions of the specified system have been demonstrated.

F. Sample strategy for identical units: No sampling, test all.

END OF AUTOMATIC TRANSFER SWITCH(ES)

3.11 RENEWABLE ENERGY SYSTEM

A. Parties Responsible to Execute Functional Test:
   1. Vendor Support Representative
   2. Electrical Contractor
   3. CxP: To witness and document testing

COMMISSIONING of ELECTRICAL SYSTEMS

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B. Integral Components or Related Equipment Being Tested: Prefunctional tests must be complete for all of the components listed below prior to performing this functional test.

1. PV array
2. Static inverters
3. Charge controllers
4. Metering
5. Bypass diodes
6. Data acquisition system (DAS)

C. Prerequisites:

1. The applicable prerequisite checklist items listed in Part 1 of this section and paragraph B above shall be listed on each functional test form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the prefunctional checklists previously completed by the installer, before the beginning of functional testing.

D. Functions/Modes Required To Be Tested, Test Methods:

1. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Specication.

<table>
<thead>
<tr>
<th>Function/Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
</tr>
<tr>
<td>1. Demonstrate all functions of the renewable energy system according to manufacturer’s instructions.</td>
</tr>
</tbody>
</table>

E. Sampling Strategy for Identical Units: No sampling, test all.

END OF RENEWABLE ENERGY SYSTEMS

3.12 DOCUMENTATION, NON-CONFORMANCE, AND APPROVAL OF TESTS

A. Documentation:

1. The CxP witnesses and documents the results of all functional performance tests using forms developed for that purpose. Prior to testing, these forms are provided to the OPM for review and approval.

B. Non-Conformance:

1. The CxP records the results of the functional test on the procedure or test form. All deficiencies identified during the verification testing are documented on a standard Issues Log form and reported to the project manager, contractors, and sub-contractors. The deficiency report includes all details of the components or systems found to be non-compliant with the parameters of the test plans. The report details the adjustments or alterations required to correct system operation and identifies the responsible party.

2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxP. In such cases the deficiency and resolution will be documented on the procedure form.

3. Deficiencies that cannot be corrected during testing will be documented on the Issues Log and subject to retest. Retesting will continue until no deficiencies remain or by Owner’s request.
4. Retesting is required when testing cannot be successfully completed. Deficiencies requiring include:
   a. Incomplete work and/or coordination with others.
   b. Inadequate preparation of systems for testing.
   c. Inadequate preplanning.
   d. Inadequate staff, equipment, tools or resources for testing.
   e. Material, equipment or construction deficiencies.
   f. Incomplete or failed test due to reasons under the Contractor’s responsibility.

5. If there is a dispute about a deficiency or who is responsible:
   a. The deficiency is documented on the Issues Log and a copy given to the OPM and CM/GC.
   b. Resolutions are made at the lowest management level possible. Additional parties are brought into the discussions as needed. Final interpretive authority is with the A/E team. Final acceptance authority is with the Project Manager. The CxP documents the resolution process.
   c. Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency and notifies the CxP that the equipment is ready to be retested.
   d. The CxP reschedules the test and the test is repeated until satisfactory performance is achieved.

C. Cost of Retesting:
   1. The cost of retesting is the responsibility of the contractor and subject to deductive change order. Correction of deficiencies and retesting are the responsibility of the contractor and are not subject to time extensions or delay claims.

D. Approval:
   1. The CxP makes formal approval of the functional performance test after review. The CxP recommends acceptance of each test to the OPM. The OPM gives final approval on each test.

3.13 OWNER’S TRAINING

A. Refer to Division 01 General Requirements and Section "Demonstration and Training" and relevant Division sections for requirements.

B. The Contractor is responsible for developing a cohesive training plan for all Divisions and Sections of work where training is specified. See technical sections for specified minimum training hours for each component and system.

C. The CM/GC shall provide the CxP a preliminary training plan and schedule related to the commissioned equipment to review and finalize incorporating comments received. The plan should include agendas including topics and objectives to be covered for each section, the instructor’s name and contact information, the anticipated duration and schedule for each session, a formal training record listing of attendees and a training evaluation form. Develop the training schedule including number of hours for each component or system in coordination with the CxP and CM that complies with the owner’s and CxP’s personnel availability.

D. The CxP shall provide each trainee with a Training Evaluation Form and at completion of training collect forms for review. Based on evaluations and OPM training review, contractor shall repeat training sessions which were determined were inadequate or incomplete.
3.14 O&M DATA and CLOSEOUT SUBMITTALS
   A. Refer to Division 01 General Requirements and Section “Closeout Submittals” and relevant Division sections for requirements.
   B. The CM/GC shall provide the CxP closeout submittals related to the commissioned equipment to review and compile into a Recommissioning Systems Manual as required.

3.15 DEFERRED TESTING
   A. Unforeseen Deferred Tests: If any test cannot be completed due to the building structure, required occupancy condition, or other deficiency, the functional testing may be delayed upon approval of the OPM. These tests are conducted in the same manner as the seasonal tests as soon as possible.

END OF SECTION 260800
SECTION 260923 - AUTOMATIC LIGHTING CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY
A. This Section provides requirements and specification criteria for the following automatic lighting control equipment:
   1. Automatic Sensing Devices.
   2. Daylight Sensing Control Devices.
   3. Daylight Harvesting Control Devices.

1.2 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.3 ACTION SUBMITTALS
A. Product Data: Submit manufacturer's data on lighting control equipment and components.
   B. Shop Drawings:
      1. Sensor layout shown on Drawings is based on the coverage patterns and specifications of the Basis for Design products. Submittals from any other listed manufacturer shall be accompanied by scaled drawings, indicating modified sensor locations and quantities, and revised layouts providing the manufacturer specific coverages and load requirements for approval by Engineer.
      2. Wiring Diagrams: For electronic time switches and photocell control circuits SPECIFIC to project.
      3. Suggested initial settings for Owner review of adjustable devices.
      4. Letters from approved ballast manufacturers that their equipment is compatible with the submitted system manufacturer.

1.4 INFORMATIONAL SUBMITTALS
A. Field Quality Control Test Reports:
   1. Include Owner’s representative signoff of adjustable settings for timing sensitivity and ambient lighting adjustments.

1.5 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For each type of product.

1.6 QUALITY ASSURANCE
A. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.
B. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section, including:

2. General Electrical Field Quality Control.

1.7 COORDINATION

A. Coordinate the exact locations of devices with the work of other tradesmen and Division contractors, and with the installation instructions and coverage limitations published by the device manufacturer.

PART 2 - PRODUCTS

2.1 GENERAL

A. Lighting control products based on automatic occupancy/vacancy/daylight sensing, shall be procured from, and provided by, a single, named, product manufacturer. Mixing multiple manufacturers for these types of products does not comply with this specification.

B. Except as otherwise noted or specified, automatic lighting control device colors, and their associated faceplate colors, shall match wiring device and faceplate colors specified in other sections. Refer to Division 26 Section "Wiring Devices."

2.2 WALL BOX STYLE - LINE VOLTAGE SENSING CONTROL DEVICES

A. Passive Infrared (PIR) Type:

1. Passive infrared sensing (heat and motion) and positive ON-OFF electromechanical switching.
2. Designed and fabricated to control line and low voltage LED light sources, as well as linear and compact fluorescent (ballasted) lighting loads.
3. Compatible with electronic fluorescent ballasts and shall not adversely affect lamp/ballast mortality.
4. Designed to operate and control lighting loads at both 120VAC and 277VAC. Minimum switch control requirements shall be as follows:
   a. At 120VAC: Zero to not less than 800VA (ballasted load).
   b. At 277VAC: Zero to not less than 1000VA (ballasted load).
5. Lighting loads shall turn on manually and shall turn off automatically after a user defined time interval, sensing no occupant presence.
   a. User selectable time delay interval - ≤30 sec. - ≥30 min.
6. A pushbutton integral to the switch shall be provided to manually turn the lighting loads on and provide override control of the off sensing function.
7. Room/Space Coverage: Not less than 180° field of view, at not less than 900 sq. ft.
8. Designed and fabricated for field installation within a standard, single gang device opening.
9. 2-wire device (not requiring a neutral wire connection), for direct 1-for-1 retrofit of standard toggle handle style lighting controls. A third "green" ground wire or terminal connection is acceptable.
10. Device shall be UL listed suitable for its use, and shall be warranted against defects in materials and/or workmanship for not less than five (5) years.
11. Acceptable Manufacturers:
   a. Basis for Design: WattStopper, Inc. – PW-100 W Series.
   b. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.3 DIGITAL LIGHTING CONTROL DEVICES

A. Shall be a system of electronic, low voltage, intelligent lighting control equipment and devices, designed, fabricated, and tested to provide automatic and manual, stand-alone, on/off and step/continuous dimming control of lighting luminaires in individual rooms and spaces.

B. Devices and equipment shall consist of not less than digitally addressable room control devices, occupancy/vacancy sensing devices, daylight sensing devices, manual control stations, and all their associated interconnection and local network wiring, cabling, electric work, etc.

C. The digital lighting equipment, when installed, shall provide small, individual, local area networks with free topology physical wired connections and digital communication protocol expressly designed to control individual local lighting loads within given spaces of a building.

   1. Digital lighting control devices shall be interconnected to their own network using CAT 5e cables, with RJ-45 connectors, providing both data communications and low voltage power to all devices.

D. Shall provide for both occupancy and vacancy types of sensing and control, with Manual-DIM/ON/Automatic OFF vacancy sensing type control, and Automatic-DIM/ON/OFF occupancy sensing type control.

E. All products shall be UL listed, suitable for their use, and shall be warranted against defects in materials, manufacture, and workmanship for not less than five (5) years.

F. Digital Lighting Room Control Modules:

   1. Shall be a combination device providing stepped dim or continuous dimming, or ON/OFF switched outputs to connected loads, and low voltage power and control data to remotely connected input devices.

   2. Shall each provide for the field termination of not less than three relay controlled step dim, continuous dimmed, or ON/OFF output loads.

      a. Each controlled output shall provide zero crossing ON/OFF switching, for each load, and shall be rated not less than 20A @120/277VAC.

      b. Each output shall provide a Class 2, 0-10VDC continuous dimming, or stepped dim control for each load.

   3. Shall provide operating voltage and current for all remotely connected control input devices.

   4. Input power shall be field connectable to both 120VAC and 277VAC branch circuits.

   5. Shall provide diagnostic LED indicators providing troubleshooting and visual feedback for:

      a. Data transmission OK.

      b. AC power connected.

      c. Connection status of each load.

      d. Configuration status of each.

   6. All components shall be housed within, or on the surface of, a single, plenum rated thermoplastic enclosure, designed for field installation over a standard 4 in. square electrical outlet box.
7. Shall be provided with wiring termination points for field connections to remote control devices.

8. Acceptable Manufacturers:
   a. Basis for Design: WattStopper LMRC Series.
   b. Acceptable Equivalents/Manufacturers as approved by Owner, submit as substitution request per Division 1.

G. Digital Lighting Control Automatic Sensors:

   1. Shall be digitally addressable, dual technology sensing devices, providing both passive infrared (PIR) and ultrasonic sensing technology to trigger a control command to the room controller.
   2. Shall operate at 24VDC, and shall provide the specified control functions through separate, remote, room controller/power supply.
      a. Room controller/power supply devices are purposely not shown on the Drawings. Contractor shall provide the required quantity of devices, as required, based on the control intend indicated on the Drawings.
   3. Coverage: Not less than a 360 deg. field of view, and not less than 625 sq. ft. coverage area at 10 ft. AFF.
   4. Shall provide a user graphical LCD display for digital calibration and electronic documentation.
   5. Shall provide for calibration and programming of the following variables:
      a. Detection Sensitivity – 0-100 percent in 10 percent increments.
      b. OFF Time delay – 1 to 30 minutes in 1 minute increments.
      c. Test mode – Five second time delay.
      d. Detection Technology – Combination PIR and Ultrasonic.
      e. Walk-through/short OFF time delay mode.
   6. Shall provide diagnostic LED indicators providing troubleshooting and visual feedback for:
      a. PIR Only Detection.
      b. Ultrasonic Only detection.
      c. Configuration mode.
      d. Load binding.
   7. All components shall be housed within, or on the surface of a single, thermoplastic enclosure, designed for field installation over a standard 4 in. electrical outlet box.
   8. Shall be provided with termination points for field wiring between other digital lighting control devices.
   9. Acceptable Manufacturers:
      a. Basis for Design: WattStopper LMDC-100 Series.
      b. Acceptable Equivalents/Manufacturers as approved by Owner, submit as substitution request per Division 1.

H. Digital Lighting Control Daylight Sensors:

   1. A UL listed, solid state electronic, low voltage, photo-conductive device designed, fabricated, and tested to operate in conjunction with a remote, 24VDC power supply/control unit, to provide closed loop, 0-10VDC continuous dimming, or bi-level step dimming, control input, based on ambient outdoor daylight intensity.
   2. Provides field adjustable calibration to initiate a low ambient daylight "ON" command.
a. A field adjustable "deadband" function shall be provided, as part of the device internal electronics, to delay the "ON/OFF" command initiation, and to prevent sensor cycling "ON/OFF" due to changing daylight conditions.

3. Entire device shall be housed in a shallow, low profile, white thermoplastic enclosure, designed for direct installation onto building construction surface, provided complete with installation hardware.

4. Acceptable Manufacturers:
   b. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

I. Digital Lighting Control Dimmers:

1. Shall be low voltage, electronic, solid-state control devices providing not less than the following features and specifications:
   a. Single rocker style, actuator allowing user to manually raise/lower lighting level, or turn controlled luminaires ON/OFF.
   b. Shall allow for and provide multi-location control of connected loads.
   c. Provides integral IR transceiver for wireless communication with digital lighting control configuration tool.
   d. LED indicators that provide visual feedback indicating that the controlled load is ON/OFF, and multi-LED vertically oriented bar graph, showing relative intensity of controlled load.
   e. LED "locator" style pilot light.

2. Devices shall be of thermoplastic construction, white in color, designed for ganged installation with other similar devices, provided with matching coverplate.

3. Devices shall be provided with termination points for field wiring between other digital lighting control devices.

4. Acceptable Manufacturers:
   b. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

J. Digital Lighting Control Switches:

1. Shall be low voltage, momentary contact, pushbutton switching devices providing the indicated switch function to interface with the digital lighting control module. Switches shall provide not less than the following features and specifications:
   a. Removable buttons for field replacement.
   b. LED on the face of each pushbutton providing visual feedback of switch/load status and switch/programming assignment.

2. Switches shall be of thermoplastic construction, white in color, designed for ganged installation with other similar devices, provided with matching coverplate.

3. Shall be provided with termination points for field wiring between other digital lighting control devices.


K. Digital Lighting Control Configuration Tool:

1. Provide a handheld, electronic, solid-state device for use in configuring the various device elements in each digital lighting control space.
2. Device shall provide local, system-wide, and per device modifications, to the various system devices, via the manufacturer's configuration software.

3. Device shall provide a user interface viewing screen, and scrolling/select buttons and menu drives command prompts, to allow user to initially install the system devices and components, and to make modifications to same, through the configuration software routines.

4. Device shall contain an integral IR transceiver, to provide for wireless communication with all system devices.

5. Provide complete with required battery supply.

6. Acceptable Manufacturers:
   b. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

L. Spare Parts: Above and beyond the quantity of devices, equipment, and components required to provide the digital lighting control indicated and specified, provide not less than the following quantity of additional spare devices:

1. Digital Lighting Control Modules – Qty. (1) One.
2. Digital Lighting Control Automatic Sensors – Qty. (2) Two.
4. Digital Lighting Control Dimmers - Qty. (2) Two.
5. Digital Lighting Control Switches - Qty. (2) Two.

2.4 LOW VOLTAGE MANUAL CONTROL SWITCHES

A. Low voltage, momentary contact type, provided for Manual-ON mode interface with automatic lighting control devices. Devices shall be:
   1. Pushbutton button type
   2. Rated not less 50mA, @ 24VDC
   3. Decorator style

B. Switches shall be similar in design to digital lighting room control switches.

C. Refer to Section 262726 – Wiring Devices, for coverplate specification.

D. Acceptable Manufacturers:
   1. Basis of Design: Wattstopper/Legrand – LVSW-100 Series
   2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.5 PROTECTIVE WIRE CAGES

A. Fabricated from not less than 12 gauge steel wire, welded into cage shapes, conforming to the various automatic lighting control device sizes, shapes, and dimensions.

B. Dipped in white rubberized paint to form a smooth, rust resistant finish, covering sharp edges and weld marks.

C. Provide with tamperproof screws and installation provisions.

D. Acceptable Manufacturers:
   1. Basis for Design:
      a. By automatic lighting control equipment manufacturer.
2. Acceptable Equivalent:

2.6 CONDUCTORS AND CABLES
   A. Wiring to Line Voltage Side Power Sources and Devices: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
   B. Class 1, 2 and 3 Control Wiring: Multiconductor cable with stranded-copper conductors not smaller than AWG size recommended or directed by equipment manufacturer.

2.7 BALANCED TWISTED PAIR CABLE
   A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      1. ADC.
      2. Alpha Wire Company; a division of Belden Inc.
      3. Belden Inc.
      4. CommScope, Inc.
      5. Draka Cableteq USA.
      7. Mohawk; a division of Belden Inc.
      8. Nexans; Berk-Tek Products.
      9. Siemon Company (The).
     10. Superior Essex Inc.
     11. SYSTIMAX Solutions; a CommScope, Inc. brand.
     12. 3M.
     13. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
   B. Category 5e Balanced Twisted Pair Cable:
      1. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 5e cable at frequencies up to 100 MHz.
      2. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 5e cables.
      3. Conductors: 100-ohm, 24 AWG solid copper.
      5. Cable Rating: Plenum.

2.8 BALANCED TWISTED PAIR HARDWARE
   A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      1. ADC.
      3. Belden, Inc.
      4. Dynacom, Inc.
      5. Hubbell, Incorporated.
      6. Leviton Commercial Networks Division.
      7. Molex Premise Networks; a division of Molex, Inc.
      8. Panduit Corp.
      9. Siemon Company (The).
10. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
11. WAGO Corp(Clear body style).

B. Description: Hardware designed to connect, splice, and terminate balanced twisted pair copper communications cable.

C. General Requirements for Cable Connecting Hardware:
1. Comply with the performance requirements of associated Category # of cable system.
2. Comply with TIA/EIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
3. Cables shall be terminated with connecting hardware of same category or higher.

D. Source Limitations: Obtain balanced twisted pair cable hardware from same manufacturer as balanced twisted pair cable, from single source.

E. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

F. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
1. Number of Terminals per Field: One for each conductor in assigned cables.

G. Patch Panel: Modular panels housing multiple numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
1. Features:
   a. Universal T568A and T5668B wiring labels,
   b. Labeling areas adjacent to conductors.
   c. 24 or 48 ports.
2. Construction: 16-gauge steel and mountable on 19-inch (483 mm) equipment racks.
3. Number of Jacks per Field: One for each four-pair conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria.

H. Patch Cords: Factory-made, four-pair cables; terminated with eight-position modular plug at each end.
1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.

I. Jacks and Jack Assemblies:
1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair 100-ohm unshielded or shielded balanced twisted pair cable.
2. Designed to snap-in to a faceplate.
3. Standards:
   a. Category 5e, unshielded balanced twisted pair cable shall comply with IEC 60603-7-2.
   b. Category 5e, shielded balanced twisted pair cable shall comply with IEC 60603-7-3.
PART 3 - EXECUTION

3.1 AUTOMATIC LIGHTING CONTROL APPLICATION

A. Provide lighting controls per the table below:

<table>
<thead>
<tr>
<th>Room Type</th>
<th>ON?</th>
<th>OFF?</th>
<th>Time Delay</th>
<th>Daylighting?</th>
<th>Dimming?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye Exam Rooms</td>
<td>Manual</td>
<td>Auto</td>
<td>3 min</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toilet Rooms (Single)</td>
<td>Auto</td>
<td>Auto</td>
<td>5 min</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toilet Rooms (multiple)</td>
<td>Auto</td>
<td>Auto</td>
<td>20 min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior Spaces (Offices/Exams/Work</td>
<td>50% Auto, 50%</td>
<td>Auto</td>
<td>1 min</td>
<td>Yes or Bi Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rooms Etc)</td>
<td>manual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior Spaces (Offices/Exams/Work</td>
<td>Manual</td>
<td>Auto</td>
<td>1 min</td>
<td>*Can do daylighting if no additional hardware is required or as code requires (Over 150W).</td>
<td>Yes or Bi Level</td>
<td></td>
</tr>
<tr>
<td>Rooms etc w/ Windows</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corridors, Lobbies &amp; Vestibules w/</td>
<td>Auto</td>
<td>Auto</td>
<td>10 min</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Windows</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corridors, Lobbies &amp; Vestibules w/</td>
<td>Auto</td>
<td>Auto</td>
<td>10 min</td>
<td></td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Windows</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient Rooms</td>
<td>Manual On</td>
<td>Manual Off</td>
<td>NA</td>
<td>Yes (As needed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conference Rooms</td>
<td>50% Auto, 50%</td>
<td>Auto</td>
<td>5 min</td>
<td>Yes</td>
<td></td>
<td>Programmable 4 button keypad.</td>
</tr>
<tr>
<td>Manual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. In general all interior spaces except those noted below shall be provided with automatic lighting control devices:

1. Stairs
2. Patient Sleeping Rooms
3. Electric Rooms
4. Mechanical Rooms

C. Unless indicated otherwise on the drawings provide Automatic lighting control devices for spaces as indicated below:

1. Wall Box Style – Line Voltage Sensing Control Devices:
   a. Single toilet bathrooms
   b. EVS closets
   c. Small storage rooms (<100 square feet)

2. Digital Automatic Lighting Control Sensors with auxiliary contacts for HVAC interface:
   a. All other interior spaces except where approved otherwise by Owner/Engineer.
3.2 INSTALLATION

A. Provide controls for all lighting.

B. Ceiling and Wall Mount Automatic Sensing Control Devices:
   
   1. Install sensors generally as shown on the Drawings.
      a. For devices provided by other than the Basis of Design manufacturer, install sensors per the approved shop drawing layouts provided under submittal requirements in Article 1.3.
   
   2. Arrange and conduct a pre-installation on-site meeting, attended by the installing contractor, sensor manufacturers' representative, and facility personnel, to verify and test sensor locations for proper coverage, line-of-sight, sensitivity, and to train facility personnel on the proper use and care of devices.
   
   3. Refer to table in specification to determine if the control devices shall be automatic or manual on along with the time delay.
   
   4. Provide, under this Contract, installation, removal, and re-installation of all sensors within 10 ft. of the locations shown on the Drawings.
   
   5. Install wall box type controls flush to wall surface, over concealed outlet boxes, roughed at AFF dimension indicated.
   
   6. Install ceiling mount devices as follows:
      a. Flush to ceiling surface, with/without outlet box, in accessible acoustical tile type ceilings, or drywall/hard plaster ceilings.
      b. On surface mounted outlet boxes in exposed construction.
      c. Not less than 36 inches from incandescent luminaires, HVAC diffusers and registers, and extreme temperature piping, devices, etc or as recommended otherwise by manufacturer. Consult with Engineer where installation requirements cannot be met.
      d. Not less than 12 inches from ballasted types of luminaires and HVAC ductwork.
      e. Avoid installations near columns, and other physical obstructions that may obscure line-of-sight views.
   
   7. Wiring between sensors, remote low voltage switches, and power supply/control units shall be plenum rated, Class II, low voltage, stranded, Teflon jacketed, insulated cable.
      a. Conductor gauge and quantity as directed by the manufacturer.
      b. Install concealed. Wiring need not be installed in raceway, if concealed. Wiring that cannot be installed concealed, shall be installed in raceway.
   
   8. Leave 10 ft. of slack cable at each sensor location, for potential sensor relocation.
   
   9. Adjust all sensors for sensitivity, line-of-sight, time delay and coverage, to the Owner's satisfaction.

C. Daylight and Daylight Harvesting Sensors:
   
   1. Locations shown in plan are approximate, and shall not be considered absolute. Verify exact locations in concert with the equipment manufacturer's/supplier's representative, for optimal performance.
   
   2. Install devices where the daylight being measured is representative of the ambient daylight condition across the entire controlled zone.
   
   3. Avoid installation in the direct path of shadowed building elements that may directly impact the proper measurement of the typical ambient daylight condition.
4. In general, unless otherwise indicated, sensors shall be installed at the underside of the ceiling material within the daylighting zone. Follow manufacturer's installation instructions for requirements.

5. Calibrate sensor sensitivities and setpoints per the manufacturer's instructions, and to provide optimum energy savings.

6. Connect to ancillary devices per the manufacturer's wiring diagrams and instructions.

7. Upon Substantial Completion of the installation, provide for the services of a duly authorized manufacturer's factory representative, who shall commission and verify that a complete and fully functional system has been installed.

8. Upon completion of the system commissioning, the factory-authorized representative shall provide training to the Owner's personnel on the adjustment and maintenance of the system. Provide for not less than eight (8) hours for this activity, and not less than two (2) total on-site visits.

D. Digital Lighting Control Devices:

1. Locations shown in plan are approximate, and shall not be considered absolute. Verify exact locations in concert with the equipment manufacturer's/supplier's representative, for optimal performance.

2. Provide on-site meeting with the equipment manufacturer's/supplier's representative to review operation and connectivity of the devices.

3. Use configuration tool to properly set and calibrate devices.
   a. Train owner's personnel in the proper use of tool.
   b. Turn over configuration tool to owner.

4. Calibrate sensor sensitivities and setpoints per the manufacturer's instructions, and to provide optimum energy savings.

5. Connect to ancillary devices per the manufacturer's wiring diagrams and instructions.

6. Upon Substantial Completion of the installation, provide for the services of a duly authorized manufacturer's factory representative, who shall commission and verify that a complete and fully functional system has been installed.

7. Upon completion of the system commissioning, the factory-authorized representative shall provide training to the Owner's personnel on the adjustment and maintenance of the system. Provide for not less than eight (8) hours for this activity, and not less than two (2) total on-site visits.

E. Power Supply/Control Units For Automatic and Daylight Sensing Control Devices:

1. Locations and quantities are purposely not shown on the Drawings. Provide the required quantities to provide the control schemes indicated, based upon the designated switching shown and sensing device current draw limitations.
   a. Locate patient room controllers/power supplies in the corridor ceiling space outside the patient room.

2. Installation - Accessible Ceilings:
   a. Install concealed, within accessible ceiling space (where accessible ceiling space exists, or is proposed), in a readily accessible and maintainable location.
      1) Install above the door on the corridor side of the room (where possible); do not located directly above patient care vicinity.
      2) Line voltage wiring connections shall be made, and shall be contained within outlet box. Low voltage wiring connections may be made outside of outlet box.

AUTOMATIC LIGHTING CONTROL EQUIPMENT 260923 - 11

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3) Provide blank, utility style, outlet box cover, and provide adhesive backed, machine printed, ID label on face of cover, reading "AUTOMATIC SENSOR POWER SUPPLY/CONTROL UNIT."

3. Installation - Non-Accessible Ceilings:
   a. Installed concealed, inside a barriered, multi-gang, electrical outlet box, roughed flush to face of drywall/hard plaster, or other type of non-accessible ceiling.
   b. Install concealed, within an immediately adjacent accessible ceiling space.
   c. Wiring connections shall be made within the outlet box, for accessibility. Maintain separation between low voltage and line voltage wiring.
   d. Provide smooth, finish type, blank outlet box cover, over concealed outlet box, and provide adhesive backed, machine printed, ID label on face of coverplate, reading "AUTOMATIC SENSOR POWER SUPPLY/CONTROL UNIT."

4. Where no ceiling exists, or is proposed, install device inside a barriered, steel electrical outlet box, exposed, within the automatic sensor space, in a readily accessible and maintainable location.
   a. Wiring connections shall be made within the outlet box. Maintain separation between low voltage and line voltage wiring.
   b. Provide blank, utility style, outlet box cover, and provide adhesive backed, machine printed, ID label on face of cover, reading "AUTOMATIC SENSOR CONTROL RELAY."

5. Connect wiring to lighting branch circuit, lighting load and sensor, per manufacturers wiring schematic.

F. Coordination:
   1. Coordinate voltage (and face color) of automatic lighting control devices.
   2. Coordinate device and coverplate color per requirements of Division 26 Section "Wiring Devices."
   3. Coordinate automatic sensor ranges, minimum/maximum wattages and field adjustments for the exact application.
   4. Coordinate power supply/control unit quantities for area/function shown on Drawings. Provide additional devices as required (i.e., one sensor and multiple power supplies for normal and generator power NEC branch separation).
   5. Coordinate electronic timer minimum/maximum wattages for the exact application.
   6. Coordinate all adjustable settings with the Owner's representative.
   7. Coordinate electronic time switch and photocell contact ratings and control circuits.

3.3 INSTALLATION – WIRING
   A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum raceway size shall be 1/2 inch (13 mm).
   B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
   C. Provide conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
   D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Electrical Identification", and as otherwise written herein.
   1. Identify controlled circuits in lighting contactors, relay panels, etc.

3.5 FIELD QUALITY CONTROL

A. Inspection and Tests:
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing" and the following additional requirements:
      a. Follow-up thermographic survey shall not be required.
      b. Prepare test and inspection reports.

B. Manufacturer's Field Service: Provide for the services of a factory-authorized service representative to setup, test and inspect installed components, assemblies, and equipment, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Automatic Sensing Controls:
      a. Verify that installed sensors cover the spaces at their intended location and adjusted angle. Confirm the following for each type of sensor:
         1) Passive Infra-Red and Passive Infra-Red Portions of Dual Technology Sensors:
            a) Verify lens is adjusted for the space geometry and size of space.
            b) Verify sensitivity is adjusted for coverage of space.
         2) Ultrasonic and Ultrasonic Portions of Dual Technology Sensors:
            a) Verify sensitivity is adjusted for coverage of space.
      b. Verify sensitivity adjustment for both types of sensors does not trigger nuisance trips from air diffusers close to the sensor.
      c. Verify sensitivity adjustment eliminates trips from movement in adjacent spaces.
      d. After lighting is triggered "ON" from sensor, confirm programmed delay "OFF" time is functional.
      e. Verify proper operation and sensitivity setting of ambient daylight override function.
      f. Simulate a power failure of the lighting system to confirm power-up restart functions are operating as specified.
      g. Sampling strategy-applied to all sensors unless noted otherwise.
         1) Of the total controlled rooms, 10 percent should be tested to confirm proper operation. If 10 percent of the first group fails the testing, select another 10 percent of the total room. If 10 percent of these rooms fail, test all remaining rooms.
   2. Daylight Sensing and Daylight Harvesting Sensor Controls:
      a. Verify that devices keep lighting "OFF" when ambient daylight levels are above the turn on design level threshold, and that lighting turns "ON" when ambient daylight levels fall below the design level threshold.
D. Lighting control devices shall be considered defective if they do not pass tests and inspections. Replace damaged and malfunctioning control equipment.

3.6 ADJUSTING

A. Occupancy and Time Based Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting sensors and time-based control devices to suit actual site-specific and/or Owner-directed conditions. Provide for not less than two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.
4. For time-based control devices, reset "OFF" time delay settings to Owner-directed interval.

3.7 DEMONSTRATION

A. Provide for the services of a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Provide for not less than 4 hours of on-site training sessions, performed multiple times, at various times during the day, to multiple teams of Owner’s personnel.

END OF SECTION 260923
SECTION 261116 - SECONDARY UNIT SUBSTATIONS

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes indoor and outdoor secondary unit substations, each consisting of the following:
      1. Incoming medium voltage section(s).
      2. Transformer(s).
      3. Secondary low voltage distribution section(s).

1.2 DEFINITIONS

1.3 SUBMITTALS
   A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements".

1.4 ACTION SUBMITTALS
   A. Product Data for Substation Components.
      1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   B. Shop drawings for each unit substation. Include the following:
      1. Layout Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
         a. Dimensioned concrete base, outline of secondary unit substation, conduit entries, and ground rod locations.
         b. Location of structural supports for structure-supported raceways.
         c. Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.
      2. Wiring Diagrams: Power, signal, and control wiring.
      3. Dimensioned plans and elevations showing major components and features.
      4. One-line diagram.
      5. List of materials.
      7. Size and number of bus bars and current rating for each bus, including mains and branches of phase, neutral, and ground buses.
      8. Short-time and short-circuit current ratings of secondary unit substations and components.
      9. Ratings of individual protective devices.
     10. Single-line and operating instructions to be mounted on unit substation.
     12. Primary Fuses: Submit recommendations and size calculations.
1.5 INFORMATIONAL SUBMITTALS
   A. Qualification Data:
      1. Source Quality Control Reports.
      2. For Testing Agency.
   B. Material Test Reports: For secondary unit substations.
   C. Factory test reports.
   D. Field quality control test reports.

1.6 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE
   A. Installer Qualifications: An experienced Installer of medium voltage electrical distribution equipment to perform the installation specified in this Section. Refer to Division 01 Section "Definitions and Standards" for definition of experienced Installer.
   B. Manufacturer Qualifications: A manufacturer regularly engaged in manufacturing substations complying with the requirements of these Specifications and experienced with at least 5 projects of similar size and scope.
   C. Source Limitations: Obtain secondary unit substation through one source from a single manufacturer.
   D. Product Options: Drawings indicate size, profiles, and dimensional requirements of secondary unit substations and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
   E. Assembly Selection: The Drawings indicate sizes, profiles and dimensional requirements of assembly equipment. Equipment having equal performance characteristics and complying with indicated maximum dimensions and profiles may be considered, provided deviations do not change the design concept intended performance, or code/future extension provision clearances. The burden of proof of equality is on the proposer a minimum of 10 days prior to bid.
   F. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   G. Comply with IEEE C2.
   H. Comply with IEEE C37.121.
   I. Comply with NFPA 70.
   J. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
      2. General Electrical Field Quality Control.

SECONDARY UNIT SUBSTATIONS

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1.8 DELIVERY, STORAGE, AND HANDLING
   A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.
   B. Coordinate delivery of secondary unit substations to allow movement into designated space.
   C. Store secondary unit substation components protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.
   D. Handle secondary unit substation components according to manufacturer's written instructions. Use factory-installed lifting provisions.

1.9 PROJECT CONDITIONS
   A. Field Measurements: Indicate measurements on Shop Drawings.
   B. Interruption of Existing electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
      1. Notify Construction Manager and Owner no fewer than fourteen (14) days in advance of proposed interruption of electric service.
      2. Do not proceed with interruption of electric service without Construction Manager's or Owner's written permission.
   C. Service Conditions: IEEE C37.121, usual service conditions.

1.10 COORDINATION
   A. Coordinate layout and installation of secondary unit substations with other construction that penetrates floors and ceilings, or is supported by them, including light fixtures, HVAC equipment, and fire-suppression-system components.
   B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.11 EXTRA MATERIALS
   A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      1. Spare fuses: Six of each type and rating of fuse and fusible device used. Include spares for the following:
         a. Potential transformer fuses.
         b. Control power fuses.
         c. Fuses and fusible devices for fused circuit breakers.
         d. Fuses for secondary fusible devices.
      2. Touchup Paint: Three half-pint containers of paint matching enclosure's exterior finish.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers:
   1. Basis of Design: Square D; Schneider Electric.
   2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.2 SECONDARY UNIT SUBSTATIONS

A. General: Provide secondary unit substations of indoor single or double ended type as indicated, with ratings and arrangement as shown on Drawings.

   1. The equipment outlined in this section shall consist of single or double-ended secondary unit substations. The general arrangement and single line diagram of the secondary unit substations shall be as shown on Drawings. The assembly shall consist of medium voltage incoming, transformer, and low voltage sections. The sections shall be bolted and connected together side by side to form a rigid, free-standing, totally enclosed assembly and to provide an in-line appearance. Each section shall be fabricated of sheet steel, and reinforced to form a rigid, free standing structure.

   2. Each incoming section shall be an air-filled cubicle of adequate size to accommodate and terminate the incoming power supply conductors including grounding provisions. The air-filled terminal box shall be adequately sized with terminals at the proper elevation for making up the required stress cones for the shielded cable. Each incoming section shall be close coupled or throat connected to the transformer section. A transition section shall be provided only as required for coordination with physical room layout.

   a. A primary switch may be used as the incoming section as required based on the project requirements.

   3. Each secondary unit substation transformer shall be close coupled to the respective switchgear. Low voltage bushings shall be directly connected to the transformer secondary main breaker in the switchgear section. A transition section shall be used only as required for coordination with physical room layout.

B. Housings: Ventilate housing to provide "natural chimney effect."

   1. Indoor Unit Arrangement: Single assembly.
   2. Enclosure Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

C. Incoming Medium Voltage Sections:

   1. The metal enclosed incoming sections shall contain an HV terminal cabinet with deadfront bushings for the transformer primary.

D. Transformer(s):

   1. Provide transformer section(s) consisting of less flammable fluid-insulated type transformer(s) with necessary connections to primary terminal cabinet and low-voltage switchgear as specified in Division 26 Section "Medium Voltage Transformers". Transformer to comply with applicable NEMA standards.
   2. Install primary connections projecting through insulated bushings; provide flexible copper secondary connections. Route neutral of secondary winding into secondary low voltage distribution section.
3. Provide loadbreak/loadmake stored energy spring assembly transformer on/off switch mounted within insulating fluid tank. Switch shall have continuous current rating of 550A and make-and-latch rating of 12kA RMS symmetrical.

E. Secondary Low Voltage Distribution Sections:

1. The low voltage sections shall consist of assemblies of free-standing metal enclosed low voltage switchgear structures. Each structure shall contain individually connected overcurrent devices or instrument compartments in the front and a full height rear compartment for buses, incoming bus connections, and feeder cable connections. The individual overcurrent device compartments shall be completely enclosed with sheet steel barriers to separate the overcurrent devices from adjacent compartments and buses.

2. The metal enclosed low voltage sections shall be as specified in Division 26 "Low Voltage Power Switchgear".

F. Grounding:

1. Each secondary unit substation shall be provided with a main copper ground bus not less than 2 inch by 1/4 inch in cross section, running throughout the length of the switchgear section near the bottom. All framework, metal enclosures, and barriers, and non-current-carrying parts of equipment shall be securely grounded, and grounding connections shall be brought to the ground bus. The metal framework of the assembly may form part of the internal grounding circuit, provided a solid and uninterrupted path is thereby assured; otherwise, grounding connections shall be furnished.

2. Two ground pads with bolted connectors for 500 KCMIL AWG stranded copper ground cable shall be provided located diagonally opposite each other on the transformer base.

G. Instrumentation:

1. Instrumentation for the low voltage section shall be as specified in Division 26 Section "Low Voltage Power Switchgear".

H. Infrared (IR) View Panes: IR transmittance lens secured and sealed to assembly enclosure to allow inspection of electrical transmission components without elevated levels of Personal Protective Equipment (PPE). Locate view panels on back of enclosure to allow use of cameras with 2X to 3X horizontal and 1.5X to 2X vertical distance to target with a maximum angle of incidence of 30 degrees to view all > 70 volt cable, bus bar, and protective device connections within the assembly. Label each window by number, instructions for use, lens material, window transmission rates, and target components; location by clock face method; and baseline emissivity (e.g. "Bus Bar Connection: 2 o'clock: E = 0.95").

I. Fabrication and Painting:

1. Fabrication and Painting shall be as specified in Division 26 Section "Medium Voltage Switchgear."

J. Identification:

1. Provide unit substation designation and other components per Division 26 Section "Electrical Identification".

2. A laminated plastic nameplate, engraved with the device designation using colors as specified in Division 26 Section "Electrical Identification" for the branch of distribution, shall be provided on each compartment door. All relays, instruments, fuses, switches, and other components mounted on the front or within the secondary unit substation shall be identified by an appropriate engraved nameplate that shows the functional number or other designation of the device.
3. Label each incoming medium voltage feeder section to indicate the feeder to which it is connected.

4. All external doors and hinged bolted panels providing access to high voltage shall be provided with "CAUTION KEEP OUT -- HIGH VOLTAGE" signs. All internal doors and screen doors proving access to high voltage shall be provided with "CAUTION -- BLADES ARE ENERGIZED WHEN SWITCH IS OPEN" signs.

5. The integrated unit substation assembly shall be provided with a nameplate indicating the manufacturer's drawing number and the following: voltage rating (KV, nominal; KV, maximum design; KV, BIL); main bus continuous rating (amperes); short-circuit ratings (amperes); asymmetrical; MVA three-phase symmetrical, at rated nominal voltage); and interrupting, momentary, and fault-closing ratings (amperes, RMS asymmetrical).

6. Framed Single Line and Operating Instructions: Frame printed Single Line, Operating Instructions and Emergency Procedures under clear acrylic plastic and mount on the end of the substation as shown on Drawings.

K. Accessories:

1. Furnish all necessary accessories and special tools required for initial erection, inspection, testing, and future maintenance of each secondary unit substation. A portable test set designed for the purpose of testing and calibrating the power circuit breakers shall be provided, in accordance with Division 26 Section "Protective Devices."

2. Automatic Throwover – Double Ended Substation:
   a. An automatic throwover scheme shall be supplied where shown on Drawings and as specified. The sequence of operation shall be such that upon loss of voltage to the line side of a main breaker and after a field adjustable time delay, that main breaker shall open and then the tie breaker shall close. Upon restoration of voltage to the line side of the main breaker and after a field adjustable time delay, the tie breaker shall open and after a field adjustable time delay, the main shall close.
   1) The following features shall also be included:
      a) A manual-automatic mode selector switch.
      b) The mains and tie shall be electrically interlocked such that no more than two can be closed at one time.
      c) If the main and tie devices open due to a fault condition, all automatic transfer shall be locked out until manually reset.
      d) Digital metering may be used for detection.
      e) PLC – Programmed by manufacturer per time delays as determined by engineer. At least two revisions by engineer shall be performed, if necessary, at no extra charge.
      f) Provide two auxiliary contacts on each main and tie device.

3. For unit substations provided initially with only a single end; provide the PLC and all controls necessary to accommodate the second end in the future. Include all wiring provisions to facilitate connection of second end and additional switchgear sections in the future.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90. Conduct switchgear and switchboard tests according to ANSI C37.51.

B. Factory Tests: Perform the following factory certified tests on each secondary unit substation:
1. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.
2. Ratios on the rated voltage connection and on tap extreme connections.
3. Polarity and phase relation on the rated voltage connection.
4. No-load loss at rated voltage on the rated voltage connection.
5. Exciting current at rated voltage on the rated voltage connection.
6. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.
8. Induced potential.
9. Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class FA rating.
   a. Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available. Delete subparagraph below if Owner does not want tests to be witnessed.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of work.
   B. Examine roughing-in of conduits and grounding systems to verify the following:
      1. Wiring entries comply with layout requirements.
      2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.
   C. Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit substation installation.
   D. Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding" have been met. Maximum ground resistance shall be 3 ohms at secondary unit substation location.
   E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
   A. Install secondary unit substations on concrete bases.
      1. Anchor secondary unit substations to concrete bases according to manufacturer's written instructions, and requirements in Division 26 Sections "Hangers and Supports" and "Vibration Controls".
   B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
3.3 IDENTIFICATION
A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Electrical Identification."
   1. Operating Instructions: Frame printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures. Mount on END of secondary unit substation.

3.4 CONNECTIONS
A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
B. Connect wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables."

3.5 CLEANING
A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.6 FIELD QUALITY CONTROL
A. Manufacturer's Field Service: Engage a factory authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
B. Inspection and Tests:
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS Sections for associated secondary unit substation components, "System Functional Tests", and "Thermographic Survey" requirements and the following additional requirements.
      a. Follow-up thermographic survey shall not be required.
      b. Prepare test and inspection reports.
C. Follow-Up Service:
   1. Voltage Monitoring and Adjusting: After Substantial Completion and during the first scheduled generator test under building load, perform the following voltage monitoring:
      a. Monitor and record bus voltage measurements using the unit mounted circuit monitor. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
      b. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
         1) Adjust transformer taps.
         2) Rebalance loads.
         3) Prepare written request for voltage adjustment by electric utility.
c. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
d. Report: Prepare a written report covering monitoring performed and corrective action taken.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 261116
SECTION 261230 – MEDIUM VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following types of power transformers with medium voltage primaries:
   1. Liquid filled transformers.

1.2 DEFINITIONS

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: Include rated nameplate, impedance, X/R ratio, and magnetizing inrush characteristics data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.

B. Shop Drawings: Diagram power and control wiring.

1.5 INFORMATIONAL SUBMITTALS
A. Qualification Data:
   1. For testing agency.
   2. Source quality control test reports.

B. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Conduit stub-up locations.
   2. Dimensioned base, outline of transformer, and required clearances.
   3. Grounding and grounding cable locations.

C. Field quality control test reports.

D. Follow up service reports.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE
A. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
   2. General Electrical Field Quality Control.

1.8 DELIVERY, STORAGE, AND HANDLING
A. Store transformers protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer’s written instructions.

1.9 PROJECT CONDITIONS
A. Service Conditions: IEEE C37.121, usual service conditions

1.10 COORDINATION
A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
B. Coordinate installation of louvers, doors, spill retention areas, and sumps. Coordinate installation so no piping or conduits are installed in space allocated for medium-voltage transformers except those directly associated with transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers:
   1. Basis of Design: Cooper Industries; Cooper Power Systems Division.
   2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.2 SYSTEM DESCRIPTION
A. Product Options: Drawings indicate size, profiles, and dimensional requirements of transformers and are based on the specific system indicated. Refer to Division 01 Section “Product Requirements.”

2.3 REGULATORY REQUIREMENTS
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
B. Comply with IEEE C2.
D. Comply with NFPA 70 and NFPA 70E.

2.4 PERFORMANCE REQUIREMENTS, GENERAL
A. Medium Voltage Transformers: Factory assembled and tested, general purpose, air cooled, and forced air cooled, dry type or liquid filled as indicated, and having characteristics and capacities as indicated.
B. Windings: 2-winding type, designed for operation with high voltage windings connected to a 3-phase, 3-wire, 60 Hz, grounded neutral system. Connections and terminal markings shall comply with IEEE C57.12.70.

MEDIUM VOLTAGE TRANSFORMERS
C. Windings: Copper or Aluminum.


E. Provide deadfront bushings and stress cone cable terminations for HV transformer connections.
   1. Elbow surge arrestors are an option if upstream equipment is does not include sufficient overvoltage protection.

F. Sound Level: Sound level of transformers without fans for this project shall be a minimum of 3 dB less than NEMA TR 1 standard sound levels for transformer type and size indicated when factory tested in accordance with applicable ANSI standard. Audible sound-level tests shall be added to routine factory tests performed on transformers for this project. (Note: NEMA Standard TR1 is available from NEMA for reference with regard to sound levels even though it has been rescinded as an overall transformer standard).

G. Forced air cooled transformers shall comply with the following requirements:
   1. Forced-air-cooling equipment shall consist of cooling fans, temperature sensing devices, and controls complete with housing, mounting devices, and wiring. Operation of cooling fans shall be automatically and sequentially controlled by temperature sensing devices. A manually operable switch shall be connected in parallel with the automatic control contacts. Controls shall be enclosed in a cabinet located on the side of the transformer 60 inches or less above the base.
   2. Cooling Fans: Propeller type, with steel blades and TEFC motors, direct drive. Motor circuits shall be individually fused or thermally protected. Fans shall have OSHA fan guards if not installed within transformer enclosure.
   3. Fan Control: Thermally operated winding temperature control devices.
   4. Fan cooling shall increase the KVA rating a minimum of 15% percent of base rating.

H. Provisions for Future Forced Air Cooling: Include the following provisions where future forced-air cooling is required:
   1. Top Liquid Temperature Sensing on Liquid Filled Transformers: Thermally operated control device with thermal element mounted in a well, and provisions for mounting the control cabinet, the conduit, and the fans.
   2. Winding Temperature Sensing on Liquid Filled Transformers: Thermally operated winding temperature control device with thermal element mounted in a well, a heating coil, and provisions for mounting the control cabinet, conduit, and fans.
   3. Winding Temperature Sensing on Dry Type Transformers: Insulated wells in all three coils for the future installation of sensors directly in the air ducts of each coil to monitor coil temperature, and provisions for future mounting of cooling fans, control cabinet, and conduit.

2.5 LIQUID FILLED TRANSFORMERS

A. Description: IEEE C57.12.00 and UL 1062, liquid filled, 2-winding transformers.

B. Insulating Liquid:
   1. Less-Flammable Liquids:
      a. Biodegradable and Nontoxic Dielectric: Listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Envirotex FR3.
C. Insulation Temperature Rise: 65/55 deg. C based maximum 55 deg. C and on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. Insulation system shall be rated to continuously allow an additional 12 percent kilovolt-ampere output, at 65 deg C temperature rise, without decreasing rated transformer life.

D. Basic Impulse Level: Comply with UL 1062.

E. Voltage and BIL Ratings:
   1. Nominal primary phase-to-phase voltage and BIL: 13,200 V, 95 kV.
   2. Nominal secondary voltage and BIL: 480Y/277 V, 30 kV.

F. Full Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

G. Cooling System: Class KNAN/KNAF, self-cooled, and with forced-air-cooled rating. Cooling systems shall includexiliary cooling equipment, automatic controls, and status indicating lights.

H. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.

I. Impedance: 5.75 percent.

J. Magnetizing Inrush Characteristics: Comply with IEEE 242 Standard not to exceed 12 times transformer full load primary current.

K. Provide loadbreak/loadmake stored energy spring assembly transformer on/off switch mounted within insulating tank fluid. Switch shall have continuous current rating of 550A and make-and-latch rating of 12kA RMS symmetrical. Provide windows for visible indication of switch position.

L. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction with provision for anchoring frame to pad, and an insulated, low voltage, neutral bushing with removable ground strap. Include the following additional accessories:
   1. Liquid-level gage.
   2. Pressure-vacuum gage.
   3. Liquid temperature indicator.
   4. Drain and filter valves (with provisions for oil sampling under load).
   5. Pressure relief device.
   6. Form fitting insulating liquid containment pan.
   7. High Pressure and Temperature alarm contacts for remote reporting to BMS.

2.6 IDENTIFICATION DEVICES

A. Per Division 26 Section "Electrical Identification."

2.7 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90.

B. Factory Tests: Perform the following factory certified tests on each transformer:
   1. Resistance measurements of all windings on rated voltage connection and on tap extreme connections.
   2. Ratios on rated voltage connection and on tap extreme connections.
   4. No load loss at rated voltage on rated voltage connection.
5. Excitation current at rated voltage on rated voltage connection.
6. Impedance and load loss at rated current on rated voltage connection and on tap extreme connections.
8. Induced potential.
9. Temperature Test: If transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class OA/FA or Class AA/FA rating.
   a. Temperature test is not required if record of temperature test on an essentially duplicate unit is available.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine areas and conditions for compliance with requirements for medium voltage transformers.
B. Examine roughing in of conduits and grounding systems to verify the following:
   1. Wiring entries comply with layout requirements.
   2. Entries are within conduit entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.
C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
D. Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding" have been met. Maximum ground resistance shall be 3 ohms at location of transformer.
E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. Install transformers on concrete bases.
   1. Anchor transformers to concrete bases according to manufacturer's written instructions, and requirements in Division 26 Section "Hangers and Supports" and "Vibration Controls".
B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 IDENTIFICATION
A. Identify field installed wiring and components and provide warning signs as specified in Division 26 Section "Electrical Identification."

3.4 CONNECTIONS
A. Ground equipment according to Division 26 Section "Grounding and Bonding."
   1. Terminate all grounding and bonding conductors on a common equipment grounding bus mounted on transformer enclosure. Install supplemental bus bars, lugs, and bonding jumpers to accommodate number of conductors for termination.
B. Connect low voltage wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables."
   1. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.
   2. Bundle associated phase, neutral, and equipment grounding conductors together within transformer enclosure. Arrange conductors such that there is not excessive strain that could cause loose connections. Allow adequate slack for expansion and contraction of conductors.

C. Terminate medium voltage cables in incoming section of substations according to Division 26 Section "Medium Voltage Cables."

3.5 FIELD QUALITY CONTROL
A. Manufacturer's Field Service: Engage a factory authorized service representative to inspect, test and adjust field assembled components and equipment installation, including connections. Report results in writing.

B. Inspection and Tests:
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS Sections for associated medium voltage transformer components, "System Functional Tests", and "Thermographic Survey" requirements and the following additional requirements.
      a. Follow-up thermographic survey shall not be required.
      b. Prepare test and inspection reports.

3.6 ADJUSTING
A. Follow-Up Service:
   1. Voltage Monitoring and Adjusting: Perform the following voltage tests and inspections after Substantial Completion:
      a. Monitor and record bus voltage measurements using the unit mounted circuit monitor. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
      b. Corrective Actions: If test results are unacceptable, the Contractor shall perform the following corrective actions, as appropriate:
         1) Adjust transformer taps.
         2) Rebalance loads.
         3) Prepare written request for voltage adjustment by electric utility.
      c. Retests: After corrective actions have been performed, repeat monitoring until satisfactory results are obtained.
      d. Report: Prepare written report covering monitoring and corrective actions performed.

3.7 DEMONSTRATION
A. Engage a factory authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain systems.

END OF SECTION 261230
SECTION 261300 – MEDIUM VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes arc resistant metal enclosed interrupter switchgear and metal clad, circuit breaker switchgear with the following components, features, and accessories:
   1. Copper, tin-plated main bus.
   2. Communication modules.
   3. Analog instruments.
   4. Relays.
   5. Surge arresters.
   7. Fungus proofing.
   8. Control battery system.
   9. Metal enclosed busway.
   10. Transfer switchgear.

1.2 DEFINITIONS

B. BIL: Basic impulse level, stated in kilovolts.
C. GFCI: Ground Fault Circuit Interrupter.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of switchgear and related equipment, include the following:
   1. Rated capacities, operating characteristics, furnished specialties, and accessories for individual interrupter switches and circuit breakers.
   2. Time current characteristic curves for overcurrent protective devices, including circuit breaker relay trip devices.

B. Shop Drawings: For each type of switchgear and related equipment, include the following:
   1. Layout Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where piping and ducts are prohibited. Include arc exhaust plenum duct details. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Identify field measurements.
   2. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show method of field assembly and location and size of each field connection. Include the following:
      a. Tabulation of installed devices with features and ratings.
      b. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
c. Drawing of cable termination compartments showing preferred locations for conduits and indicating space available for cable terminations.
d. Floor plan drawing showing locations for anchor bolts and leveling channels.
e. Current ratings of buses.
f. Short-time and short-circuit ratings of switchgear assembly.
g. Nameplate legends.
h. Mimic bus diagram.
i. Utility company's metering provisions with indication of approval by utility company.

3. Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.

4. Wiring Diagrams: For each type of switchgear and related equipment, include the following:
   a. Power, signal, and control wiring.
   b. Three line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.
   c. Schematic control diagrams.
   d. Diagrams showing connections of component devices and equipment.
   e. Schematic diagrams showing connections to remote devices.

5. Factory Quality Control Test Reports:
   a. Manufacturer Arc Resistant Qualification Certification: Submit certification that switchgear assembly and arc exhaust plenum will withstand potential worst case arc flash conditions generated from arc flash study.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. Source quality control test reports.
   2. Testing Agency.
   3. Professional Engineer for seismic calculations.

B. Field quality control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchgear and switchgear components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   2. Time current curves, including selectable ranges for each type of overcurrent protective device.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer of medium voltage electrical distribution equipment to perform the installation specified in this section. Refer to Division 01 Section "Definitions and Standards" for definition of experienced Installer.

B. Manufacturer Qualifications: Manufacturer shall be a member of NEMA, regularly engaged in manufacturing switchgear complying with the requirements of these Specifications, experienced with at least five (5) projects of similar size and scope.
C. Source Limitations: Obtain each type of switchgear and associated components through one source from a single manufacturer.

D. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
   2. General Electrical Field Quality Control.


1.8 DELIVERY, STORAGE, AND HANDLING
A. Deliver in sections of lengths that can be moved past obstructions in delivery path as indicated.
B. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.9 PROJECT CONDITIONS
A. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:
   1. Ambient temperature not exceeding 122 degrees F (50 degrees C).
   2. Altitude of 600 feet above sea level.
B. Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.
C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear and adjacent surfaces and other items. Comply with indicated maximum dimensions.
D. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Construction Manager and Owner no fewer than 14 days in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without Construction Manager's or Owner's written permission.

1.10 COORDINATION
A. Coordinate layout and installation of switchgear and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.
B. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.11 EXTRA MATERIALS
A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses: Six (6) of each type and rating used. Include spares for future transformers, control power circuits, and fusible devices.

2. Indicating Lights: Six (6) of each type installed.

3. Touchup Paint: Three (3) containers of paint matching enclosure finish, each 0.5 pint (250 mL).

B. Maintenance Tools: Furnish tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include the following:

1. Fuse handling tool.
2. Extension rails, lifting device, transport or dockable dolly or mobile lift, and all other items necessary to remove circuit breaker from housing and transport to remote location.
3. Racking handle to move circuit breaker manually between connected and disconnected positions, and a secondary test coupler to permit testing of circuit breaker without removal from switchgear.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 Articles where titles below introduce lists, the following requirements apply to product selection:

1. Basis of Design:
   a. Square D; Schneider Electric.
   b. ABB

2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.2 REGULATORY REQUIREMENTS

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Assembly Selection: The drawings indicate sizes, profiles and dimensional requirements of assembly equipment. Equipment having equal performance characteristics and complying with indicated maximum dimensions and profiles may be considered, provided deviations do not change the design concept intended performance or code/future extension provision clearances. The burden of proof of equality is on the proposer a minimum of 10 days prior to bid.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with IEEE C2.

2.3 MEDIUM VOLTAGE SWITCHGEAR, GENERAL REQUIREMENTS

A. General: Factory assembled, factory tested, with functions and circuit assignments for each bay and types, characteristics, and ratings of busses and disconnecting, and protective devices as indicated. Switchgear shall conform to NEMA Standard SG5, "Power Switchgear Assemblies."

B. Description: Factory assembled and tested, and complying with IEEE C37.20.1.
C. Ratings: Suitable for application in 3 phase, 60 Hz, solidly grounded neutral system.
D. System Voltage: 13.8 kV nominal; 15 kV maximum

2.4 METAL ENCLOSED INTERRUPTER SWITCHGEAR

A. Manufacturers:
   1. Square D; Schneider Electric.

B. Comply with IEEE C37.20.7. Provide arc resistant switchgear, Type 2C.


D. Ratings: Comply with standard ratings designated in IEEE C37.20.3 for maximum rated voltage specified.
   1. Main Bus Rating: Refer to rating indicated on the drawings.

E. Interrupter Switches: Stationary, gang operated, and suitable for application at maximum short-circuit rating of integrated switchgear assembly.
   1. Rating: As indicated on the drawings, continuous duty and load break.
   2. Duty Cycle, Fault Closing: 25,000 or asymmetrical A.
   3. Switch Action: No external arc and no significant quantities of ionized gas released into the enclosure.
   4. Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored energy operating mechanism.
   5. Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.
   6. Protective Shields: Cover live components and terminals.
   7. Fuses: De-energized if switch is open.

F. Mechanical Interlock: Prevent opening switch compartment door unless switchblades are open, and prevent closing switch if door is open.

G. Window: Permit viewing switchblade positions if door is closed.

H. Infrared (IR) View Panes: IR transmittance lens secured and sealed to assembly enclosure to allow inspection of electrical transmission components without elevated levels of Personal Protective Equipment (PPE). Locate view panels on front and back of enclosure to allow use of cameras with 2x to 3x horizontal and 1.5x to 2x vertical distance to target with a maximum angle of incidence of 30 degrees to view all 70 volt cable, busbar, and protective device connections within the assembly. Label each window by number, instructions for use, lens material, window transmission rates, and target components; location by clock face method; and baseline emissivity (e.g. Busbar Connection: 2 o'clock: E = 0.95”).

I. Power Fuses: Comply with the following and with applicable requirements in NEMA SG 2:
   1. Indicator: Integral with each fuse to indicate when it has blown.
   2. Mounting: Positively held in position with provision for easy removal and replacement from front without special tools.
   3. Current Limiting Fuses: Full range, fast replaceable, current limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.

J. For arc resistant switchgear, provide a barrier between the load break switch compartment which accessing the fuse compartment after the switch has been locked open.
2.5 COMPACT 5.5 KV LOAD INTERRUPTER SWITCHES

A. Manufacturers:

B. General: Stationary mounted in switchgear and including the following features:
   1. Arrangement and Rating: Gang operated, rated 200 amperes for continuous duty and for load break. Suitable for operation up to the maximum short circuit rating of the integrated switchgear assembly.
   2. Dead front assembly with no rear access.
   3. Switch Action: No external arc. Interrupting action shall not liberate significant quantities of ionized gas into the enclosure.
   4. Switch Construction: Switch blade material shall be copper. Switch and all associated parts including electrical and mechanical connections shall be supported entirely from the interior framework of the structure. Switch shall have external manual operating handle with lock open padlocking provisions for multiple padlocks.
   5. Operating Mechanism: Quick make, quick break, stored energy type.
   6. Barriers: Phase barriers for the full length of the blades and fuses for each pole. If a protective barrier is used, it shall be designed for easy removal. The barrier material shall allow visual inspection of the switch with the barrier in place.
   7. Protective shield to cover potentially live parts and terminals.
   8. Fuses: De-energized when switch is open.
   9. Mechanical interlock shall prevent opening the door unless the switch blades are open and closing the switch if the door is open.
   10. Window: For viewing switch blade positions.

C. Power Fuses: Current limiting ratings as indicated. Each fuse shall have an indicator to show it has blown. Fuses shall meet applicable requirements of NEMA Standard SG 2, "High Voltage Fuses," and the following:
   1. Fuses shall be positively held in position with provision for easy removal and replacement from the front without the use of special tools.
   2. Spares: Each fusible bay shall include three fuses in use and three spare fuses in storage clips. Provide hold down clips to prevent fuses from accidentally or seismically loose within the bay.

D. Current Limiting Fuses: Fuses shall be of the full range, fast replaceable, current limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from the tube.

E. Interrupting rating of fuses at rated system voltage shall be as indicated.

2.6 METAL CLAD CIRCUIT BREAKER SWITCHGEAR

A. Manufacturers:
   1. Square D; Schneider Electric.

B. Comply with IEEE C37.20.7. Provide arc resistant switchgear, Type 2B.

C. Nominal Interrupting Capacity Class: 350 MVA.

D. Ratings: Comply with IEEE C37.04.
   1. Main Bus Rating: As indicated on the drawings A, continuous.
E. Circuit Breakers: Three pole, single throw, electrically operated, drawout mounted units using three individual, vacuum sealed interrupter modules and including the following features:

1. Designed to operate at rated voltage to interrupt fault current within its rating within five cycles of trip initiation. For systems with X/R ratio of 17 or less, transient voltage during interruption shall not exceed twice the rated line-to-ground voltage of the system.

2. Contact Wear Indicator: Readily accessible to field maintenance personnel.

3. Minimum of six Type A and six Type B spare contacts.

4. Interchangeability: Circuit breakers are interchangeable with vacuum circuit breakers of same current and interrupting ratings.

5. Operating Mechanism: Electrically charged, mechanically and electrically trip free, stored energy operated.

   a. Closing speed of moving contacts to be independent of both control and operator.

   b. Design mechanism to permit manual charging and slow closing of contacts for inspection or adjustment.

      1) Control Power: 120 V ac for closing and tripping.

   c. Provide shunt trip capability independent of overcurrent trip.

6. Provisions for remote racking system.

F. Test Accessories: Relay and meter test plugs.

G. Arc Flash Protection system (AFPS): Assembly integrated microprocessor based system with the following features:

1. Function:

   a. Manually set assembly electronic relays to instantaneous trip “AFPS” mode with no time delay thus defeating system relay coordination to minimize arc flash incident energy. This theoretically allows assembly maintenance or troubleshooting to be more safely performed by qualified personnel with the assembly energized.

   b. Manual reset to “normal” mode shall reset relay settings per coordination study. Assure backup electronic storage of normal protective device settings which can be automatically downloaded to relay.

2. Manual AFPS-Normal Switch:

   a. Dedicated switch located on front of each electronic overcurrent protection relay.

   b. Local or remote indicator lights shall indicate operating modes.

3. Rotating Beacon:

   a. Mount rotating industrial grade amber beacon on top of each assembly to remind personnel that AFPS system is activated.

4. Power Supply:

   a. Manufacturer standard with control transformers integral to associated assembly.

5. Identification:

   a. AFPS switch identification, switch AFPS and normal mode, and appropriate warning labels shall be engraved laminated acrylic or melamine label type as specified in Division 26 Section “Electrical Identification.”

6. Remote Alarm Provision:

   a. Two sets of normally open and normally closed contacts.
H. Light Sensing Arc Flash Protection System (LSAFPS): Assembly integrated microprocessor based system with the following features:

1. Fiber optic arc flash light sensors to detect light produced by an arc flash event.
   a. Loop Sensor: To cover bus differential protection zone and provide entire switchgear lineup assembly and tripping of all circuit breakers.

2. Fast acting protection relay which receives light sensor event, verifies an overcurrent incident to prevent false tripping, then signals associated circuit breaker to trip.

3. Current transformer to monitor breaker overcurrent incident.

4. Remote Alarm Provision:
   a. Two sets of normally open and normally closed contacts.

2.7 FABRICATION

A. Indoor Enclosure: Steel.

B. Outdoor Enclosure: Galvanized steel, weatherproof construction; integral structural steel base frame with factory applied asphaltic undercoating.

1. Each compartment shall have the following features:
   a. Structural design and anchorage adequate to resist loads imposed by 125 mph (200 km/h) wind.
   b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation.
   c. Louvers equipped with insect and rodent screen and filter and arranged to permit air circulation while excluding rodents and exterior dust.
   d. Power for heaters, lights, and receptacles to be provided as indicated.

2. Weatherproof internal aisle construction shall have the following features:
   a. Common internal aisle of sufficient width to permit protective device withdrawal, disassembly, and servicing in aisle.
   b. Aisle access doors at each end with exterior locking provisions and interior panic latches.
   c. Aisle space heaters operating at one-half or less of rated voltage, thermostatically controlled.
   d. Vaporproof LED aisle lights with low temperature ballasts, controlled by wall switch at each entrance.
   e. GFCI duplex receptacles, a minimum of two, located in aisle.
   f. Aisle ventilation louvers equipped with insect and rodent screen and filter, and arranged to permit air circulation while excluding rodents and exterior dust.

C. Finish: Manufacturer’s standard gray finish over rust inhibiting primer on phosphatizing treated metal surfaces.

D. Metal Enclosed Bus Transition Unit: Arranged to suit bus and adjacent units.

E. Incoming Line Unit: Arranged to suit incoming line.

F. Outgoing Feeder Units: Arranged to suit distribution feeders.

G. Auxiliary Compartments: Arranged to suit house meters, relays, controls, and auxiliary equipment; isolated from medium voltage components.

H. Auxiliary contacts for remote closed and open position indication.
I. Protective Device Indicating Lights: Shall be mounted on front door of the switchgear, be removable from the front, and shall be General Electric, Type ET-5 or Westinghouse Minalite type, complete with low voltage lamp, receptacle, and resistor, suitable for operation from a 120 volt ac source, as required. Fifteen percent (15%) spare lamps and two (2) lamp pullers of the bayonet type shall be provided per switchgear lineup.

1. Red shall indicate open.
2. Green shall indicate closed.

J. Key Interlocks: Arranged to affect interlocking schemes indicated.

K. Provisions for Future Key Interlocks: Mountings and hardware required for future installation of locks, where indicated.

L. Rubber Mats:

1. Provide corrugated, non-conductive, rubber mats per Division 26 Section "Hangers and Supports":
   a. In operating and maintenance aisles on all sides of each electrical assembly.
   b. As shown on Drawings or otherwise extending the longer of the electrical assembly or associated housekeeping pad and 4 foot minimum width.

2.8 COMPONENTS

A. Main Bus: Aluminum, tin plated; full length of switchgear.

B. Ground Bus: copper, tin plated; minimum size 1/4 by 2 inches (6 by 50 mm); full length of switchgear.

C. Bus Insulation: Covered with flame retardant insulation.

D. Metal Clad Switchgear Arc Exhaust Plenum: Provided by switchgear manufacturer to be mounted on and above switchgear to allow arc byproduct gasses to be dispersed properly and not to be reflected back into the area that could be occupied by personnel and to assure potential back pressure does not cause a failure of the arc resistant integrity of the switchgear assembly. Where physical clearances are not possible above the switchgear, provide an extended arc exhaust plenum to vent to the outside of the building that is not accessible to personnel. Provide arc byproduct, rain, sso, and vermin proof vents intended for such use and environmental conditions.

1. For Main-Tie-Main switchgear arrangements, provide barrier separating one main and the tie-breaker from the other main and extend two dedicated output arc ducts to the building exterior.


1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and minimum C100 accuracy class for connected relays, meters, and instruments.

F. Multifunction Digital Metering Monitor: Microprocessor based unit suitable for three or four wire systems, listed and labeled by an NRTL, and with the following features:

1. Inputs from sensors or 5-A current transformer secondaries, and potential terminals rated to 600 V.
2. Switch selectable digital display with the following features:
   a. Phase Currents, Each Phase: Plus or minus 1 percent.
   b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.

d. Three Phase Real Power: Plus or minus 2 percent.

e. Three Phase Reactive Power: Plus or minus 2 percent.

f. Power Factor: Plus or minus 2 percent.

g. Frequency: Plus or minus 0.5 percent.

h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.

i. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.

G. Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs.


1. Class:

   a. Intermediate Class for incoming feeders.

   b. Distribution Class for outgoing feeders.

2. Install in cable termination compartments in each phase of circuit.

3. Coordinate rating with circuit voltage.

4. Shall be UL listed for use with the lightning protection system.

I. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

J. Control Power Supply: Control power transformer supplies 120 V control circuits through secondary disconnect devices. Include the following features:

1. Dry type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.

2. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.

   a. Secondary windings connected through relay(s) to control bus to affect an automatic transfer scheme.

   b. Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.

3. Control Power Fuses: Primary and secondary fuses provide current limiting and overload protection.

K. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2. Conductors sized according to NFPA 70 for duty required.

2.9 LINEUP 1MVS1

A. Ratings:

1. System Voltage: 13.8 KV Y

2. BIL: 95 KV

3. Frequency: 60 Hz
4. Main Bus: 1200 ampere continuous
5. MVA Short Circuit: 500 MVA symmetrical
6. Ground Bus: 1/4 inch by 2 inch full perimeter
7. Maximum Temp: 40 degrees C
8. Minimum Temp: 25 degrees C
9. Elevation: 600 feet
10. Arc Resistant Type: 2B

B. Front Left to Right Lineup Assembly Section Arrangement:

<table>
<thead>
<tr>
<th>Identification</th>
<th>Section Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>52/M1</td>
<td>Main Breaker Number 1</td>
</tr>
<tr>
<td>UM1</td>
<td>Utility Metering Number 1</td>
</tr>
<tr>
<td>52/F1 and 52/F3</td>
<td>Feeder Breakers Number F1 and F3</td>
</tr>
<tr>
<td>52/F5 and 52/F7</td>
<td>Feeder Breakers Number F5 and F7</td>
</tr>
<tr>
<td>52/SPR and 52/SPC</td>
<td>Feeder Breaker Spare and Space</td>
</tr>
<tr>
<td>52/T1</td>
<td>Tie Breaker Number 1</td>
</tr>
<tr>
<td>52/SPR and 52/SPC</td>
<td>Feeder Breaker Spare and Space</td>
</tr>
<tr>
<td>52/F6 and 52/F8</td>
<td>Feeder Breakers Number F6 and F8</td>
</tr>
<tr>
<td>52/F2 and 52/F4</td>
<td>Feeder Breakers Number F2 and F4</td>
</tr>
<tr>
<td>UM2</td>
<td>Utility Metering Number 2</td>
</tr>
<tr>
<td>52/M2</td>
<td>Main Breaker Number 2</td>
</tr>
</tbody>
</table>

C. Lineup Equipment:

1. The following is a list, by quantity and type, of the protective devices (relays, timers), instruments, switches, etc. as a design basis for each lineup cubicle. This list is submitted for guidance only. The switchgear shall be designed and equipped to meet the functions specified.

   a. For each main metal clad breaker 52/M1 and 52/M2, the following equipment is anticipated:
      1) 3 - Type 50/51 relays.
      2) 1 - Type 50N/51N relay.
      3) 3 - Type 87 relays.
      4) Line and load side bushing CTs.
      5) 3 - Load side PTs.
      6) Electric utility termination and testing provisions.
      7) Load side station class lightning arresters, rated XX KV, type MCOV.
      8) Kirk key interlocks.
      9) Electric line switch interlock.
      10) Multifunction Digital Metering Monitor.
      11) Position contacts and pilot lights.

   b. For tie breaker 52/T1, the following equipment is anticipated:
      1) Kirk key interlocks.
      2) Electric line switch interlock (one 89 relay required for interlock).
      3) (6) CTs.
      4) Position contacts and pilot lights.
5) The kirk key and electric line switch interlock shall permit only two of the following devices to be closed at one time:
   a) 52/M1.
   b) 52/M2.
   c) 52/T1.

c. For each utility metering section UM1 and UM2, the following equipment is anticipated:
   1) Electric utility current and potential transformer provisions with access padlocking. The utility metering instrument transformers will be as follows:
      a) CT – (3) <XXXX>.
      b) PT – (3) <XXXX>.

d. For each feeder and spare breaker 52/F#, the following equipment is anticipated:
   1) 3 - Type 50/51 relays.
   2) 1 - Type 50N/51N relay.
   3) Line and load side bushing CTs.
   4) Multifunction Digital Metering Monitor.
   5) Position contacts and pilot lights.

e. Make provision for addition of future sections at both ends of the switchgear.

2.10 LINEUP 1MVS2

A. The following is a list, by quantity and type, of the protective devices (relays, timers), instruments, switches, etc. as a design basis for each lineup cubicle. This list is submitted for guidance only. The switchgear shall be designed and equipped to meet the functions specified.

B. Ratings:
   1. System Voltage: 4.16 KV
   2. BIL: 60 KV
   3. Frequency: 60 Hz
   4. Main Bus: 1200 ampere continuous
   5. MVA Short Circuit: 350 MVA symmetrical
   6. Ground Bus: 1/4 inch by 2 inch full perimeter
   7. Maximum Temp: 40 degrees C
   8. Minimum Temp: 25 degrees C
   9. Elevation: 600 feet
   10. Arc Resistant Type: 2B

C. Front Left to Right Lineup Assembly Section Arrangement:

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<td>UM1</td>
<td>Utility Metering Number 1</td>
</tr>
<tr>
<td>FS1</td>
<td>Feeder Switch Number FS1</td>
</tr>
<tr>
<td>FS2</td>
<td>Feeder Switch Number FS2</td>
</tr>
<tr>
<td>FS3</td>
<td>Feeder Switch Number FS3</td>
</tr>
<tr>
<td>SPR</td>
<td>Feeder Switch Spare</td>
</tr>
</tbody>
</table>

D. Lineup Equipment:
1. The following is a list, by quantity and type, of the protective devices (relays, timers), instruments, switches, etc. as a design basis for each lineup cubicle. This list is submitted for guidance only. The switchgear shall be designed and equipped to meet the functions specified.

   a. For main switch MS1, the following equipment is anticipated:
      1) 3 – Electronic fuses of ratings indicated on single-line Drawing.
      2) 3 – Load side CTs.
      3) 3 – Load side PTs.
      4) Electric utility termination and testing provisions.
      5) Load side station class lightning arresters, rated XX KV, type MCOV.
      6) Multifunction Digital Metering Monitor.
      7) Position contacts and pilot lights.

   b. For each utility metering section UM1 and UM2, the following equipment is anticipated:
      1) Electric utility current and potential transformer provisions with access padlocking. The utility metering instrument transformers will be as follows:
         a) CT – (3) <XXXX>.
         b) PT – (3) <XXXX>.

   c. For each feeder and spare switch FS#, the following equipment is anticipated:
      1) 3 – Current limiting fuses of ratings indicated on single-line Drawing.
      2) Position contacts and pilot lights.

   d. Make provision for addition of future sections at both ends of the switchgear.

2.11 REMOTE CIRCUIT BREAKER CONTROL STATION

A. Remote Tripping Device: Wall mounted control station box to match switchgear enclosure with:
   1. Mimic bus nameplate depicting bus, circuit breaker positions, and source or feeder identifications.
   2. Circuit breaker close and trip operators matching functionality on switchgear assembly circuit breaker compartment.

2.12 GROUNDING AND TEST DEVICE SYSTEM

A. General: System shall be suitable for phasing out, testing, or grounding the switchgear bus or the feeder when the device is installed in place of the breaker at any circuit breaker position. System shall include the following:
   1. Portable grounding and test device interchangeable with draw out medium voltage circuit breakers and providing interlocked access to either bus or feeder. Device shall be electrically operated.
   2. Control cabinet for system, permanently mounted in vicinity of switchgear.
   3. Portable remote control station for grounding and test device.
   4. Coupler cable of adequate length for connecting between device, when inserted in any switchgear cubicle, and control cabinet.
   5. Coupler cable for connecting between control cabinet and remote control station, to permit operating device from a safe distance. (50 foot cable length).
   6. Permanent control power wiring from control cabinet to power source.
   7. Fitted cover for device, of heavy duty plastic.
B. Approval: Final system design shall be as approved by the power company and the Architect.
C. Automatic Control Systems.

2.13 REMOTE RACKING SYSTEM
A. Provide a motorized remote racking system for new switchgear assemblies. System shall include:
1. Power supply from assembly control transformer, 120 VAC source.
2. Front mounted 120 VAC receptacle for temporary motor and pendant control.
3. Permanently installed racking motors and drive system for each vacuum circuit breaker.
4. Remote control panel wall mounted at remote location for each assembly.
5. Control system and logic for remote racking function.
6. Interconnecting wiring between system components and to remote control panels.

2.14 CIRCUIT BREAKER TEST CABINET
A. Test Cabinet: Separately mounted test cabinet containing pushbuttons for breaker closing and tripping, control relay, fuses, and secondary coupler with cable approximately 9 feet long. Provide a set ofsecondary devices for operating the breaker when removed from the switchgear and moved to the vicinity of the test cabinet. Cabinet shall have provisions for storage of test and maintenance accessories. Locate the cabinet as indicated.

2.15 IDENTIFICATION
A. Per Division 26 Section "Electrical Identification."

2.16 SOURCE QUALITY CONTROL
A. Before shipment of equipment, perform the following tests and prepare test reports:
   1. Production tests on circuit breakers according to ANSI C37.09.
   2. Production tests on completed switchgear assembly according to IEEE C37.20.2.
B. Assemble switchgear and equipment in manufacturer's plant and perform the following:
   1. Functional tests of all relays, instruments, meters, and control devices by application of secondary three phase voltage to voltage circuits and injection of current in current transformer secondary circuits.
   2. Functional test of all control and trip circuits. Connect test devices into circuits to simulate operation of controlled remote equipment such as circuit breaker trip coils, close coils, and auxiliary contacts. Test proper operation of relay targets.
C. Prepare equipment for shipment.
   1. Provide suitable crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.
   2. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.

2.17 FACTORY FINISHES
A. Finish: Manufacturer's standard color finish applied to equipment before shipping.

2.18 RUBBER MATS
A. Provide corrugated, nonconductive, rubber mats:

MEDIUM VOLTAGE SWITCHGEAR
1. In operating and maintenance aisles on all sides of each electrical assembly including battery racks.
2. As shown on Drawings or otherwise extending the longer of the electrical assembly or associated housekeeping pad and 4 foot minimum width.

B. Comply with ANSI/ASTM D178 Type II, Class 2 requirements including:
   1. Minimum dielectric strength of 30,000 volts AC RMS.
   2. Maximum use of 17,000 volts AC RMS.
   3. Minimum 1/4 inch thickness.

C. Acceptable Manufacturers:
   1. American Floor Mats.
   2. Mats Etc.
   3. Mats, Inc.
   4. Ranco Industries, Inc.
   5. Salisbury, a Division of Honeywell.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine elements and surfaces to receive switchgear for compliance with requirements for installation tolerances, required clearances, and other conditions affecting performance.
      1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
   A. Anchor switchgear assembly to 4 inch (100 mm), channel iron sill embedded in floor or concrete base and attach by bolting.
      1. Sills: Select to suit switchgear; level and grout flush into floor or concrete base.
      2. Anchor medium voltage switchgear to floor or concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 26 Sections "Hangers and Supports."
   B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchgear units and components.
   C. Support metal enclosed bus transition unit assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.
      1. Design each fastener and support to carry 200 lb (90 kg) or 4 times the weight of bus assembly, whichever is greater.
      2. Support bus assembly to prevent twisting from eccentric loading.
      3. Support bus assembly with not less than 3/8 inch (10 mm) steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
      4. Fasten supports securely to building structure according to Division 26 Section "Hangers and Supports."
   D. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.
E. Construct rated firestop assemblies where bus assemblies penetrate fire rated elements such as walls, floors, and ceilings. Seal around penetrations according to Division 07 Section "Penetration Firestopping."

F. Install weatherseal fittings and flanges where bus assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight. See Division 07 Section "Joint Sealants" for materials and application.

G. Install a concrete curb at least 3 inches (75 mm) high around bus assembly floor penetrations.

H. Coordinate bus assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.

I. Tighten bus assembly joints with torque wrench or similar tool recommended by bus assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.

3.3 IDENTIFICATION

A. Identify field installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Electrical Identification."

B. Diagram and Instructions:
   1. Frame under clear acrylic plastic on front of switchgear.
      a. Operating Instructions: Printed basic instructions for switchgear, including control and key interlock sequences and emergency procedures.
      b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.
   2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

3.4 CONNECTIONS

A. Cable terminations at switchgear are specified in Division 26 Section "Medium Voltage Cables."

B. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque tightening values.

C. Ground equipment according to Division 26 Section "Grounding and Bonding."

D. Connect wiring according to Division 26 Sections "Low Voltage Electrical Power Conductors and Cables" and "Medium Voltage Cables."

3.5 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Manufacturer's Field Service: Engage a factory authorized service representative to perform the following:
   1. Inspect switchgear, wiring, components, connections, and equipment installation. Test and adjust components and equipment.
2. Assist in field testing of equipment including pretesting and adjusting of automatic power factor correction units.

C. Inspection and Tests:
1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS Sections for associated medium voltage switchgear components, "System Functional Tests", and "Thermographic Survey" requirements and the following additional requirements.
   a. Follow-up thermographic survey shall not be required.
   b. Prepare test and inspection reports.

3.6 ADJUSTING
A. Set field adjustable, protective relay trip characteristics according to results in Division 26 Section "Overcurrent Protective Device Coordination Study".

3.7 CLEANING
A. On completion of installation, inspect interior and exterior of switchgear. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair damaged finishes.

3.8 PROTECTION
A. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

3.9 DEMONSTRATION
A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 261300
SECTION 262150 – HEALTHCARE POWER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes healthcare power systems including:
   1. Single phase isolated power panels.
   2. Duplex single phase isolated power panels.
   3. Three phase isolated power panels.
   4. Laser isolated power systems.
B. Related Division 20 work specified elsewhere which apply to this Section:
   1. "Common Work Results, Division 21 through 28."

1.2 REFERENCES
A. NFPA 70 - Article 517.
B. NFPA 99 - Health Care Facilities.
C. UL Standard 1022 - Line Isolation Monitor.

1.3 DEFINITIONS
A. IPS: Isolated Power System.
B. LIM: Line Isolation Monitor.

1.4 COMPATABILITY
A. All new healthcare power systems shall be of the same manufacturer's product line and keyed alike.
B. Panelboards, wiring devices, etc. within healthcare power systems shall be per appropriate Division 26 sections and of common project manufacture.

1.5 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.6 ACTION SUBMITTALS
A. Product Data:
   1. Submit manufacturer's product data, specifications, and wiring diagrams, indicated by assembly type, for each healthcare power system.
   2. Include complete raceway and wiring diagrams for each assembly device. Include 120 volt wire submittal.
   3. Submit evidence of UL labeling on Shop Drawings, specific to project.
B. Shop Drawings: Submit shop drawings including:
   1. Voltage, ampere, AIC, and integrated interrupting ratings.
3. Dimensioned drawings.
4. Finish and mounting type.
5. Main, neutral, and ground bus drawings.
7. Lugs.
8. UL and NEMA labeling for applications required.
10. Lock hardware.
11. Number and size of spare breakers.
12. Tag numbers.

1.7 INFORMATIONAL SUBMITTALS
A. Qualification Data for Field Testing Organization: Certificates, signed by the Contractor, certifying that the organization complies with the requirements specified in Quality Assurance. Include list of complete projects with project names, address, names of Architects and Owners, plus other information specified.
B. Field Testing:
   1. Equipotential grounding test reports.
   2. Isolated power systems test reports.

1.8 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Manuals.
B. Record Documents.

1.9 QUALITY ASSURANCE
A. Listing and Labeling: Provide assemblies that are listed and labeled.
   1. The terms "listed" and "labeled": As defined in the National Electrical Code, Article 100.
B. Field-Testing Organization Qualifications: To qualify for acceptance, the testing organization must demonstrate based on evaluation of organization-submitted criteria conforming to ASTM E 699, that it has the experience and capability to conduct satisfactorily the testing indicated.
C. Electrical Component Standard: Components and installation shall comply with NFPA 70, "National Electrical Code".
D. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
   2. General Electrical Field Quality Control.

PART 2 - PRODUCTS

2.1 SINGLE PHASE ISOLATED POWER PANELS
A. Construction:
1. Backbox:
   a. Flush mounted.
   b. Minimum #12 gauge galvanized steel with welded studs for interior mounting plate.
   c. Maximum Depth: 8 inches.
   d. Modular dividers, wireways, and knockouts shall separate wiring of different voltages serving horizontal and vertical device compartments as well as a field wiring compartment for connection to remote devices.

2. Front Cover:
   a. Type 304 #12 gauge stainless steel with No. 4 brushed finish with trim appropriate for backbox mounting and associated stainless steel mounting hardware.
   b. Flush circuit breaker section door and latch.
   c. Integral LIM.
   d. Devoid of ventilation grille or louver as panel shall be rated to accept internal component generated heat. Front panel temperature shall not exceed 30 degrees C under full load conditions.
   e. Identification label per Division 26 Section "Electrical Identification."

3. Interior integral mounting plate assembly shall include:
   a. Ground bus.
   b. Isolation transformer.
   c. Line isolation monitor (LIM).
   d. Panelboard.
   e. Terminals for wiring to remote LIM and alarm panels.

B. Ground Bus (System and Patient Ground Point):
   1. Thirty #6 to #14 AWG terminals and one 250 KCMIL to #6 AWG main terminal point compression lug 1/8 inch by 3/4 inch copper bar.

C. Isolation Transformer:
   1. Primary voltage and capacity as indicated on drawings, 120 volt secondary, single phase, 60 hertz, with electrostatic shield between windings.
   2. Class H rated insulation.
   3. Temperature rise limited to 115 degrees C above ambient under full load conditions.
   4. Maximum sound level shall be 35 dB.
   5. Total leakage current to ground from transformer secondary winding in compliance with UL 1047.

D. Line Isolation Monitor:
   1. UL 1022 compliant.
   2. Front panel mounted with:
      a. Hazard meter or digital display.
      b. Normal and alarm status indicator lights.
      c. Alarm buzzer.
      d. Silencing switch.
      e. Test switch.
      f. Microprocessor based self-testing, self-calibrating.
      g. Provisions for transmission of status and metered conditions to remote LIM and nurses’ station alarm panel.
3. Monitors:
   a. The impedance from each secondary conductor to ground and displays the system total hazard current (THC) on an ammeter. The LIM itself shall not contribute more than 25 microamperes to the system total hazard current.
   b. All combinations of resistive and capacitive faults whether they are balanced, unbalanced, or hybrid.

4. Alarms:
   a. Visibly and audibly when the total hazard current reaches 5 milliamperes.

5. Resets to normal automatically when the fault condition is corrected.

E. Fault Locator System:
   1. Interior mounted with:
      a. Overcurrent protection.
      b. Isolation fault locator modules.
      c. Jumper wire with quick connects.
      d. Control Transformer (CT) strips.
      e. LED indicators.

F. Panelboard:
   1. Project manufacturer in compliance with Division 26 Sections "Panelboards" and "Protective Devices" complete with:
      a. Thermal magnetic circuit breakers.
      b. 2-pole main primary circuit breaker.
      c. 2-pole main secondary circuit breaker.
      d. 2-pole branch circuit breakers as shown on Drawings.
      e. Minimum 10,000 amperes interrupting capacity.
      f. Circuit directory.

G. Acceptable Manufacturers:
   1. Basis of Design: Square D, Schneider Electric
   2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.2 DUPLEX SINGLE PHASE ISOLATED POWER PANELS
   A. Two separate single phase isolated power panels each as described in paragraph above with barriered separation and single 304 satin stainless steel cover.
   B. Acceptable Manufacturers:
      1. Basis of Design: Square D, Schneider Electric
      2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.3 THREE PHASE ISOLATED POWER SYSTEMS
   A. Construction:
      1. Backbox:
         a. Flush mounted.
b. Minimum #14 gauge galvanized steel with welded studs for interior mounting plate.
c. Maximum Depth: 14 inches.
d. Modular dividers, wireways and knockouts shall separate wiring of different voltages serving horizontal and vertical device compartments as well as a field wiring compartment for connection to remote devices.

2. Front Cover:
   a. Type 304 #12 gauge stainless steel with No. 4 brushed finish with trim appropriate for backbox mounting and associated stainless steel mounting hardware.
   b. Flush circuit breaker section door and latch.
   c. Integral LIM.
   d. Void of ventilation grilles or louver as panel shall be rated to accept internal component generated heat. Front panel temperature shall not exceed 30 degrees C under full load conditions.
   e. Identification label per Division 26 Section "Electrical Identification."

3. Interior integral mounting plate assembly shall include:
   a. Ground bus.
   b. Isolation transformer.
   c. Line isolation monitor (LIM).
   d. Panelboard.
   e. Control system to remote receptacle and associated remote LIM modules which to assure only one receptacle operational at one time.
   f. Terminals for wiring to remote LIM and alarm panels.

B. Ground Bus:
   1. Thirty #6 to #14 AWG terminals and one 250 KCMIL to #6 AWG main terminal point compression lug 1/8 inch by 3/4 inch copper bar.

C. Isolation Transformer:
   1. 480 volt delta primary, 208Y/120 volt secondary, three phase, 60 hertz, with electrostatic shield between windings.
   2. Class H rated insulation.
   3. Temperature rise limited to 80 degrees C above ambient under full load conditions.
   4. Maximum sound level shall be 35 dB.
   5. Total leakage current to ground from transformer secondary winding in compliance with UL 1047.

D. Line Isolation Monitor:
   1. UL 1022 compliant.
   2. Front panel mounted with:
      a. Hazard meter or digital display.
      b. Normal and alarm status indication lights.
      c. Alarm buzzer.
      d. Silencing switch.
      e. Test switch.
      f. Provisions for transmission of status and metered conditions to remote LIM and nurses’ station alarm panel.

3. Monitors:
a. The impedance from each secondary conductor to ground and displays the system total hazard current (THC) on an ammeter. The LIM itself shall not contribute more than 15 microamperes to the system total hazard current.

b. All combinations of resistive and capacitive faults whether they are balanced, unbalanced or hybrid.

4. Alarms:
   a. Visibly and audibly when the total hazard current reached 5 milliamperes.
   b. Resets to normal automatically when the fault condition is corrected.

E. Fault Locator System:
   1. Interior mounted with:
      a. Overcurrent protection.
      b. Isolation fault locator modules.
      c. Jumper wire with quick connects.
      d. Control Transformer (CT) strips.
      e. LED indicators.
   2. Activation upon LIM alarm.

F. Panelboard:
   1. Project manufacturer in compliance with Division 26 Sections "Panelboards" and "Protective Devices".
   a. Thermal magnetic circuit breakers.
   b. 3-pole main primary circuit breaker.
   c. 3-pole main secondary circuit breaker.
   d. 3-pole and 2-pole branch circuit breakers as shown on Drawings.
   e. Minimum 10,000 amperes interrupting capacity.
   f. Circuit directory.

G. Remote Receptacle Modules:
   1. Flush mounted #14 gauge backbox.
   2. Type 304 #12 gauge stainless steel front cover with No. 4 brushed finish with trim appropriate for backbox mounting and associated stainless steel mounting hardware.
   3. Flush receptacle door and internal hinge hardware to limit dust entry.
   4. Receptacle to match portable equipment of project manufacturer used in Division 26 Section "Wiring Devices."
   5. Integral remote LIM.

H. Acceptable Manufacturers:
   1. Basis of Design: Square D, Schneider Electric
   2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.4 LASER ISOLATED POWER PANELS
   A. Isolated power panels as described in paragraph above with primary voltage and capacity as indicated on drawings, 208 volt secondary, single phase, 60 hertz, isolation transformer and 2-pole branch circuit breakers.
   B. Acceptable Manufacturers:
1. Basis of Design: Square D, Schneider Electric
2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.5 COMMUNICATIONS
A. Remote Monitoring:
1. The LIM shall be able to be monitored remotely via communications devices. manufacturer shall provide communications devices capable of communication via various industry-standard protocols.
   a. Communication Protocols:
      1) BACNet.
2. The communication capability should be able to integrate into any industry standard Building Management System (BMS) and/or Network Management System (NMS). The UPS must also be able to be monitored via any standard Internet browser (i.e. Internet Explorer, Chrome, or Firefox).
B. Remote Monitoring Parameters: LIM shall communicate the following values:
   1. Program the following alarms:
      a. Total hazard current Over User Limit (PhsA-B combined, User Limit threshold at 5 milliamperes).
      b. General Alarm (all other system alarms).
   2. Program the following Status:
      a. System Status.
   3. Program the following inputs:
      a. System Output hazard current.

2.6 WIRING
A. Secondary side branch circuit wiring:
   1. Minimum #12 AWG copper, XHHW, 90 degrees C, with dielectric constant 3.5 or less.
   2. Color Coding:
      a. Refer to Division 26 Section "Low Voltage Electrical Conductors and Cables."
   3. Acceptable Manufacturers:
      a. Refer to Division 26 Section "Low Voltage Electrical Conductors and Cables."

PART 3 - EXECUTION
3.1 GENERAL
A. Review Drawings for healthcare power systems, designations, device locations, and special features.
B. Provide interconnecting wire and cable between components or modules as specified and recommended by the manufacturer's representative.
3.2 COORDINATION

A. Coordinate equipment wiring, operational voltages, controls, conduit etc., for proper system mountings and interconnections. Provide any necessary auxiliary equipment for electrical interfaces and device mountings. The auxiliary equipment shall provide for, but not limited to:
   1. Device mounting arrangement (horizontal/vertical) and associated alterations.

B. Verify and furnish all necessary dimensional data to the appropriate Division in time to prepare wall spaces and supports for installations.

C. Coordinate protective device manufacturers for project standardization.

D. Coordinate minimal conduit fill to minimize leakage currents per manufacturer’s recommendation.

3.3 SHIPPING AND STORAGE

A. Ship healthcare power systems in conditioned transportation housing and store assemblies in conditioned space with temperature ranges recommended by manufacturer prior to installation to prevent damage due to expansion and contraction and to prevent entrance of moisture.

3.4 INSTALLATION

A. General:
   1. Install backboxes and frame supports and/or mountings of size and type recommended by manufacturer’s representative to suit assembly and location shown on Drawings.
   2. Install assemblies.
   3. Extend conduit rough-in for remote alarms and branch circuits per Division 26 Sections "Conduit Rough-In Systems" and "Raceways". Prevent foreign matter and moisture from entering raceways by using temporary construction closure protection.
   4. Make appropriate connection to incoming and outgoing power, signal, and communication devices.

B. Isolated Power Systems:
   1. Keep isolated power branch circuits in independent raceways from other systems.
   2. Make conduit runs direct to limit conductor length. Horizontal runs in walls and point-to-point runs in ceilings are permitted.
   3. Pull wire without the use of lubricants.
   4. Minimize conduit fill to minimize leakage currents.
   5. Assure that branch circuits within the panels are not bundled to minimize leakage current.
   6. Ground isolation transformer electrostatic shield to room equipotential ground bus.

C. Line Isolation Monitor:
   1. Isolated Power Panel mounted in room, a LIM to be installed flush-mounted within panel.
   2. Isolated Power Panel mounted exterior to room, a remote LIM to be installed within room.

3.5 FIELD QUALITY CONTROL

A. Provide the services of a fully qualified factory technician provided by the manufacturer to perform the field testing.

B. Inspection and Tests:
1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", NFPA 99, ANSI/NETA ATS Sections for associated Healthcare power systems components, "System Functional Tests", and "Thermographic Survey" requirements and the following additional requirements.
   a. Follow-up thermographic survey shall not be required.
   b. Prepare test and inspection reports.

C. Equipotential Grounding System:
   1. Record ground impedance from every grounded metal object and ground jack to associated patient ground point using ground integrity tester.
   2. Record potential between every grounded metal object and ground jack in patient vicinity with nearby branch circuits energized, using ground integrity tester.
   3. Submit recordings with test report.

D. Isolated Power System:
   1. Energize the system with all branch breakers turned off and record the meter reading.
   2. Energize each branch breaker, one at a time, and record the meter readings individually.
   3. Submit recordings with test report.
   4. Ground system testing shall be in conformance with the requirements of NFPA 99.

3.6 TRAINING

A. Upon completion of all tests, the factory technician shall meet with hospital medical and maintenance staff to thoroughly explain the operation of the equipment installed, and the need and procedure of periodically testing and logging tests results. The technician shall furnish log books to the maintenance department, enter the first readings of all panels in these logs books, and clearly instruct the hospital maintenance staff how to enter future readings.

B. All questions from the hospital staff shall be answered completely and thoroughly at this time.

END OF SECTION 262150
SECTION 262200 - LOW VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY
A. This section includes general purpose and specialty dry type transformers (and voltage regulators) with windings rated 600 V or less, with capacities up to 1000 KVA.

1.2 COORDINATION
A. Coordinate size and location of concrete bases. Cast anchor bolt inserts into bases. Comply with concrete, reinforcement, and formwork requirements specified in Division 03.
B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: For each type and size of transformer, include:
   1. Ratings, internal wiring diagrams, weights, impedances, audible noise level, dimensional plans, sections, and elevations showing installed devices, and materials lists.
   2. Energy Efficiency Data:
      a. No load and full load losses at 35 percent of nameplate rating.
      b. Linear load efficiency at 35 percent of nameplate rating per NEMA TP-2.
      c. Linear load efficiency at 25 percent, 50 percent, 75 percent, and 100 percent of nameplate rating.
   3. UL Label Certification.
B. Shop Drawings:
   1. Wiring Diagrams: From manufacturer differentiating between manufacturer-installed and field-installed wiring.

1.5 INFORMATIONAL SUBMITTALS
A. Qualification Data:
   1. Source Quality Control Test Reports.
   2. For Testing Agency.
   3. Manufacturers grounding provisions to comply with requirements herein.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: Include operation and maintenance manuals.
B. Record of tap adjustments.
1.7 QUALITY ASSURANCE
A. Manufacturer Qualifications: Member firm of NEMA who is regularly engaged in manufacturing components that comply with the requirements of these Specifications and that have been used on at least five projects of similar size and scope as this Project.
B. Source Limitations: Obtain each transformer type through one source from a single manufacturer.
C. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
   2. General Electrical Field Quality Control.

1.8 DELIVERY, STORAGE, AND HANDLING
A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

PART 2 - PRODUCTS
2.1 MANUFACTURERS
A. Manufacturers:
   1. Basis of Design: Square D; Schneider Electric
   2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.2 REGULATORY REQUIREMENTS
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
B. Comply with:
   1. ANSI C57.12.01/NEMA ST-20 Dry-Type Transformer for General Applications.
   4. IEEE 1100 – IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment
   5. NEMA ST1 – Specialty Transformers.
2.3 GENERAL TRANSFORMER DESIGN CRITERIA

A. Description: Factory assembled and tested air cooled units of types specified, having characteristics and ratings as indicated. Units shall be designed for 60-Hz service.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Transformers Rated 15 kVA and Larger: Comply with 2016 DOE energy-efficiency levels.

D. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

E. Coils: Continuous windings without splices except for taps.
   1. Internal Coil Connections: Brazed or pressure type.
   2. Coil Material: Copper or Aluminum.

F. Equipment Ground Bus: Copper 2 inch by 1/4 inch by necessary length to accommodate independent grounding conductor lugs per transformer grounding details.
   1. Provide transformer enclosure bonding jumper and ground bus provisions on side wall of enclosure easily accessible from front cover per Division 26 Section "Grounding and Bonding."

G. Transformer primary and secondary terminals shall be front connected for ease of installation and maintenance. Ensure minimum one inch clearance to enclosure from terminals and lugs. Coil leads shall be suitable to receive solderless crimp type lugs on a rigid braced and insulated terminal board.

H. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

I. Shipping Restraints: Paint or otherwise color code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

J. Ratings:
   1. As shown on Drawings.

2.4 GENERAL PURPOSE, DRY-TYPE TRANSFORMERS

A. Comply with NEMA Standard ST 20 "Dry-Type Transformers for General Applications."

B. Windings: 2-winding type. Three phase transformers shall use one coil per phase in primary and secondary. Primary winding shall be Delta connected and secondary winding shall be Wye connected unless otherwise shown on Drawings.

C. Sound Level: Per NEMA ST 20 standard sound levels for transformer type and size indicated.

D. Transformers shall be generally installed in an indoor ventilated enclosure, NEMA 250, Type 2. Other enclosure types, as shown on Drawings, may be:
1. Indoor, ventilated, dripproof.
2. Outdoor, ventilated, raintight, NEMA 3R.
3. Totally enclosed, nonventilated.
4. Totally enclosed, nonventilated, suitable for outdoor use.

E. Insulation Class: 220 degrees C class for transformers larger than 15 kVA.
F. Insulation Temperature Rise: 115 degrees C maximum rise above 40 degrees C.
G. Minimum efficiencies shall be per 2016 US DOE 10 CFR Part 431 and local energy codes.
H. Taps: For transformers 15 kVA and larger, full capacity taps in high-voltage winding as follows:
   1. Six 2-1/2 percent taps, 2 above and 4 below rated high-voltage.
I. Provide K-13 rated transformers for units serving primarily IT or other similar non-linear loads.
J. Accessories: The following accessory items are required as shown on Drawings:

2.5 BUCK-BOOST TRANSFORMERS
A. Description: Self-cooled, two-winding dry type, rated for continuous duty.
C. Ratings: As shown on Drawings, and for continuous duty.
D. Type: Self-cooled, dry type, connected as auto transformers to provide the percentage of buck or boost indicated.
E. Enclosure: Suitable for the location indicated.
F. Sound Level: Minimum of 3 dB less than NEMA ST 1 standard for transformer of type and size indicated when factory tested in accordance with that standard.

2.6 CONTROL AND SIGNAL TRANSFORMERS
A. Description: Self-cooled, two-winding dry type, rated for continuous duty.
C. Ratings: As shown on Drawings and recommended by manufacturer of served load and for continuous duty. Where ratings are not shown on Drawings, provide capacity in excess of load.
D. Type: Self-cooled, two-winding dry type.
E. Enclosure: Indoor, except as indicated.

2.7 IDENTIFICATION DEVICES
A. Nameplates: Engraved, self-adhesive laminated-plastic nameplate for each transformer. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.8 SOURCE QUALITY CONTROL
A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.
   1. Resistance measurements of all windings at the rated voltage connections and at all tap connections.

LOW VOLTAGE TRANSFORMERS
2. Ratio tests at the rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at the rated voltage connections.
4. No load losses, and excitation current and rated voltage at the rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at the rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation Resistance Tests:
   a. High voltage to ground.
   b. Low voltage to ground.
   c. High voltage to low-voltage.
9. Temperature tests.
   a. Temperature test is not required if record of temperature test on an essentially duplicate unit is available.

B. Factory Sound Level Tests: Conduct prototype sound level tests on production-line products.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
E. Environment: Enclosures shall be rated for the environment in which they are located.
F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 COORDINATION
A. Determine actual transformer pad size and conduit openings.
B. Provide neutral and ground conductor termination modifications for other than general purposes transformers per manufacturers recommendations.

3.3 INSTALLATION
A. General:
   1. Arrange equipment to provide adequate spacing for cooling air circulation.
   2. Identify transformers in accordance with Division 26 Section "Electrical Identification."
   3. Tighten electrical connectors and terminals in accordance with manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
B. Wall Mounted Type:
   1. Install on bracket support fabricated from channel framing providing neoprene-in-shear vibration isolators between transformer base and bracket.
   2. Brace transformers as specified in Division 26 Section "Vibration Controls."

C. Floor Mounted Type:
   1. Install transformer on a 4 inch concrete pad, at least 6 inches clear of walls or other obstructions. Provide neoprene-in-shear vibration isolators between transformer and base. Secure transformer to base using anchor bolts. Provide a soft rubber sleeve to prevent bolt shank from contacting transformer base.
   2. Construct concrete bases and anchor floor-mounted transformers according to manufacturer’s written instructions and requirements in Division 26 Sections "Hangers and Supports" and "Vibration Controls."

D. Ceiling Mounted Type:
   1. Install on trapeze hanger support, capable of supporting transformer, fabricated from channel framing and rod, providing neoprene-in-shear vibration isolators between transformer base and trapeze. Provide a soft rubber sleeve to prevent bolt shank from contacting the transformer base.
   2. Brace transformers as specified in Division 26 Section "Vibration Controls."

3.4 GROUNDING
A. Ground transformers and tighten connections to comply with tightening torques specified in UL Standard 486A.
B. Ground transformers per requirements of Division 26 Section "Grounding and Bonding," and the following:
   1. Equipment ground bus connections per NEC 250.
   2. Grounding electrode connections per NEC 250.
   3. Grounding details shown on Drawings.
   4. Split-bolt grounding connections and bonding jumper lugged to painted enclosure is not acceptable.

3.5 FIELD QUALITY CONTROL
A. Manufacturer’s Field Service: Engage a factory authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
B. Tests and Inspections:
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS "Transformers, Dry-Type, Air-Cooled, Regulating Apparatus, Voltage", "System functional Tests", and "Thermographic Survey" requirements, and the following additional requirements:
      a. Follow-up thermographic survey shall not be required.
      b. Prepare test and inspection reports.
3.6 ADJUSTING
   A. After energization and prior to Substantial Completion with at least partial building load online, perform and record instantaneous voltage measurements to verify voltage balance and stability are acceptable. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
   B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

3.7 CLEANING
   A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.8 PROTECTION
   A. Temporary Heating: Apply temporary heat in accordance with manufacturer’s recommendations within enclosure of each transformer throughout periods during which equipment is not in a space that is continuously under normal control of temperature and humidity.

END OF SECTION 262200
SECTION 262300 – LOW VOLTAGE POWER SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes, metal-enclosed, low-voltage power circuit-breaker switchgear assemblies rated 1000 V and less for use in ac systems.

1.2 DEFINITIONS
   B. GFCI: Ground Fault Circuit Interrupter.

1.3 SUBMITTALS
   A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements".

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of switchgear, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
   B. Shop Drawings: For each type of switchgear and related equipment.
      1. Layout Drawings: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:
         a. Tabulation of installed devices with features and ratings.
         b. Enclosure types and details.
         c. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
         d. Bus configuration with size and number of conductors in each bus run, including phase, neutral, and ground conductors of main and branch buses.
         e. Current rating of buses.
         f. Short-time and short-circuit current rating of switchgear assembly.
         g. Nameplate legends.
         h. Utility company's metering provisions with indication of approval by utility company.
         i. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
      2. Wiring Diagrams: Power, signal, and control wiring.
   C. Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.

1.5 INFORMATIONAL SUBMITTALS
   A. Qualification Data: For testing agency.
B. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where pipe and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchgear and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

B. Record Documents:

1. Updated mimic-bus diagram reflecting field changes after final switchgear load connections have been made, for record.

1.7 QUALITY ASSURANCE

A. Source Limitations: Obtain switchgear through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

C. Assembly Selection: The Drawings indicate sizes, profiles, and dimensional requirements of assembly equipment. Equipment having equal performance characteristics and complying with indicated maximum dimensions and profiles may be considered, provided deviations do not change the design concept intended performance, or code/future extension provision clearances. The burden of proof of equality is on the proposer a minimum of 10 days prior to bid.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NFPA 70.

F. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:

2. General Electrical Field Quality Control.

G. Comply with ANSI/NETA ATS – Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems for field testing including:

1. ANSI C37.20: Switchgear Assemblies.
2. ANSI C37.20.1: Metal Enclosed Low Voltage Power Circuit Breaker Switchgear.
3. ANSI C37.20.7: Arc Resistant Testing.
5. ANSI C37.16: Low Voltage Power Circuit Breakers and AC Power Circuits.
6. ANSI C37.17: Trip Devices for AC and General Purpose DC Low Voltage Power Circuit Breakers.
7. ANSI C37.50: Equipment - Low Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures.

1.8 DELIVERY, STORAGE, AND HANDLING
A. Deliver switchgear in sections of lengths that can be moved past obstructions in delivery path.
B. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.9 PROJECT CONDITIONS
A. Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.
B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Construction Manager and Owner no fewer than fourteen (14) days in advance of proposed interruption of electric service.
   2. Do not proceed with interruption of electric service without Construction Manager's or Owner's written permission.
C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
D. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
   1. Ambient Temperature: Not exceeding 40 deg C.

1.10 COORDINATION
A. Coordinate layout and installation of switchgear and components with other construction that penetrates ceilings or is supported by them, including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.
B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.11 EXTRA MATERIALS
A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Six of each type and rating used. Include spares for potential transformer fuses, control power fuses, and fuses and fusible devices for fused circuit breakers.
   2. Indicating Lights: Equal to 10 percent of amount installed for each size and type, but no fewer than 6 of each size and type.
   3. Touchup Paint: 3 containers of paint matching enclosure finish, each 0.5 pint (250 mL).
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers:
   1. Basis of Design: Square D; Schneider Electric
   2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.2 RATINGS

A. Nominal System Voltage: 480/277V, 4-wire, 60 Hz.
B. Main Bus Continuous: As scheduled on Drawings.
C. Short Time and Short Circuit Current: As scheduled on Drawings.

2.3 FABRICATION

A. Factory assembled and tested and complying with IEEE C37.20.1.
B. Indoor Enclosure Material: Steel.
C. Finish: IEEE C37.20.1, manufacturer's standard gray finish over a rust inhibiting primer on phosphatizing-treated metal surfaces.
D. Section barriers between main and tie circuit breaker compartments shall be extended to rear of section.
E. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.
F. Switchgear overall depth shall be no less than 80" to allow adequate conduit access.
G. Circuit breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors.
H. Fabricate enclosure with removable, hinged, rear cover panels to allow access to rear interior of switchgear.
I. Auxiliary Compartments: Match and align with basic switchgear assembly.
J. Busbars connect between vertical sections and between compartments. Cable connections are not permitted.
   1. Main Phase Bus: Uniform capacity the entire length of assembly.
   3. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers. Bus space for future circuit breakers shall not be less than the 25% of the initial installed number of branch circuit breakers. Bus shall extend the full height of the section mounting space.
   5. Use copper for connecting circuit-breaker line to copper bus.
   6. Contact Surfaces of Buses: Silver plated.
7. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.

8. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4 by 2 inches (6 by 50 mm).


10. Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.

11. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.

12. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.

2.4 INSTRUMENTATION


1. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.

2. Current Transformers: Ratios as indicated; burden and accuracy class suitable for connected relays, meters, and instruments.

B. Multifunction Digital-Metering Monitor: UL-listed or -recognized, microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.

2. Switch-selectable digital display of the following:
   a. Phase Currents, Each Phase: Plus or minus 1 percent.
   b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
   c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
   d. Three-Phase Real Power: Plus or minus 2 percent.
   e. Three-Phase Reactive Power: Plus or minus 2 percent.
   f. Power Factor: Plus or minus 2 percent.
   g. Frequency: Plus or minus 0.5 percent.
   h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
   i. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Indicating Lights: Breaker open and breaker closed, for main and bus tie circuit breakers interlocked with either each other or with external devices.

D. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

2.5 COMPONENTS

A. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

B. Control Power Supply: Control power transformer supplying 120-V control circuits through secondary disconnect devices. Include the following features:
1. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.

2. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.
   a. Secondary windings connected through a relay or relays to control bus to effect an automatic transfer scheme.
   b. Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.


4. Fuses are specified in Division 26 Section "Protective Devices."

C. Infrared (IR) View Panes: IR transmittance lens secured and sealed to assembly enclosure to allow inspection of electrical transmission components without elevated levels of Personal Protective Equipment (PPE). Locate view panels on back of enclosure to allow use of cameras with 2X to 3X horizontal and 1.5X to 2X vertical distance to target with a maximum angle of incidence of 30 degrees to view all greater than 70 volt cable, busbar, and protective device connections within the assembly. Label each window by number, instructions for use, lens material, window transmission rates, and target components; location by clock face method; and baseline emissivity (e.g. "Busbar Connection: 2 o'clock: $E = 0.95$").

D. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:
   1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
   2. Conductors sized according to NFPA 70 for duty required.

2.6 LOW VOLTAGE DRAWOUT POWER CIRCUIT BREAKERS

A. Description: Comply with IEEE C37.13.

B. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.

C. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
   1. Normal Closing Speed: Independent of both control and operator.
   2. Slow Closing Speed: Optional with operator for inspection and adjustment.
   4. Operation counter.
   5. Digital Power Meter.

D. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
   1. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
   2. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
   3. Field-adjustable, time-current characteristics.
   4. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
5. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."


7. Pickup Points: Five minimum, for instantaneous-trip functions.

8. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:
   a. Three-wire circuit or system.
   b. Four-wire circuit or system.
   c. Four-wire, double-ended substation.

9. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.

E. Auxiliary Contacts: For interlocking or remote indication and monitoring of circuit-breaker position and meter data, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two Type "a" and two Type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.

F. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:
   1. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.
   2. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:
      a. Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
      b. Disconnected Position: Primary and secondary devices and ground contact disengaged.

G. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.

H. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.

I. Operating Handle: One for each circuit breaker capable of manual operation.

J. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.

K. Key Interlocks: Arranged so keys are attached at devices indicated per requirements of Division 26 Section "Protective Devices." Mountings and hardware are included where future installation of key-interlock devices is indicated.

L. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.

M. Shunt-Trip Devices: Where indicated.
N. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

2.7 ZERO VOLTAGE VERIFICATION SYSTEM
A. General: Assembly integrated voltage test system with the following features:
B. Function:
1. Voltage indicating lights and test ports. This theoretically allows assembly maintenance or troubleshooting to be more safely performed by allowing qualified personnel to verify that equipment is deenergized.
C. Voltage Ports:
1. Dedicated ports located on front of assembly.
D. Make: Grace Engineered Products Inc. – VTS Series.

2.8 ACCESSORIES
A. Accessory Set: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.
1. Racking handle to manually move circuit breaker between connected and disconnected positions.
2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
4. Remote Racking and Control device which is capable of inserting, removal, open and closing of drawout breakers while the operator is outside the flash protection boundary.
B. Automatic Throwover – Double Ended Switchgear:
1. An automatic throwover scheme shall be supplied where shown on Drawings and as specified. The sequence of operation shall be such that upon loss of voltage to the line side of a main breaker and after a field adjustable time delay, that main breaker shall open and then the tie breaker shall close. Upon restoration of voltage to the line side of the main breaker and after a field adjustable time delay, the tie breaker shall open and after a field adjustable time delay, the main shall close.
   a. The following features shall also be included:
   1) A manual-automatic mode selector switch.
   2) The mains and tie shall be electrically interlocked such that no more than two can be closed at one time.
   3) If the main and tie devices open due to a fault condition, all automatic transfer shall be locked out until manually reset.
   4) Digital metering may be used for detections.
   5) PLC: Programmed by manufacturer per time delays as determined by Engineer. At least two revisions by Engineer shall be performed, if necessary, at no extra charge.
   6) Provide two auxiliary contacts on each main and tie device.
C. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.
D. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
E. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

2.9 IDENTIFICATION
A. Identification Materials: Refer to Division 26 Section "Electrical Identification." Identify units, devices, controls, and wiring.
B. Compartment Nameplates: Engraved plastic laminate or metal nameplate for each compartment, mounted with corrosion-resistant screws.
C. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads. Include as-built data for low-voltage power switchgear and connections as follows:
   1. Frame size of each circuit breaker.
   2. Trip rating for each circuit breaker.
   3. Conduit and wire size for each feeder.

PART 3 - EXECUTION
3.1 EXAMINATION
A. Examine elements and surfaces where switchgear will be installed for compliance with installation tolerances, required clearances, and other conditions affecting performance.
   1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. Comply with applicable portions of NECA 400.
B. Anchor switchgear assembly to 4-inch, channel-iron floor sill embedded in concrete base and attach by bolting.
   1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 3 inches (75 mm) in all directions beyond the maximum dimensions of switchgear unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Division 26 Section "Hangers and Supports."
C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear units and components.

3.3 IDENTIFICATION
A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Electrical Identification."
B. Diagram and Instructions:
   1. Frame and mount under clear acrylic plastic on the end of the switchgear or as shown on Drawings.
      a. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
      b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.
2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

3.4 CONNECTIONS
A. Ground equipment according to Division 26 Section "Grounding and Bonding."
B. Connect wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL
A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.
B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
   1. Inspect switchgear installation, including wiring, components, connections, and equipment. Test and adjust components and equipment.
   2. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 26 Sections.
   3. Complete installation and startup checks according to manufacturer's written instructions.
   4. Assist in field testing of equipment including pretesting and adjusting of equipment and components.
   5. Report results in writing.
C. Inspection and Tests:
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS Sections for associated low voltage power switchgear components, "System Functional Tests", and "Thermographic Survey" requirements and the following additional requirements.
      a. Follow-up thermographic survey shall not be required.
      b. Prepare test and inspection reports.
   2. Prior to Substantial Completion, test and certify operation of the overhead lift crane to ensure smooth and unhindered movement of the lift across the entire length of the switchgear. Test both with and without a typical drawout breaker attached. Coordinate test with Owner a minimum of 7 days in advance of scheduled test.
D. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make appropriate feeder changes, if not handled downstream.
   1. Measure as directed during period of normal system loading.

3.6 ADJUSTING
A. Set field-adjustable, protective-relay trip characteristics according to results in Division 26 Section "Protective Device Coordination."
3.7 CLEANING
   A. On completion of installation, inspect interior and exterior of switchgear. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.8 PROTECTION
   A. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

3.9 DEMONSTRATION
   A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 262300
SECTION 262333 - GENERATOR DOCKING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary
      Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section includes the following low voltage generator docking devices:
      1. Cam style docking tap.

1.3 DESCRIPTION:
   A. The generator docking device is used to connect a portable generator to the electrical distribution
      system.

1.4 SUBMITTALS
   A. General: Submit the following in accordance with Division 26 Section "Common Work Results
      for Electrical."

1.5 ACTION SUBMITTALS
   A. Product Data: Identify specific products submitted for use including manufacturers’ options,
      accessories, and product data.

1.6 INFORMATIONAL SUBMITTALS
   A. Field quality control test reports.

1.7 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For Generator Docking Devices and accessories to include in
      emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE
   A. Source Limitations: Obtain Generator Docking Devices through one source from a single
      manufacturer.
   B. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70,
      Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for
      intended use.

1.9 PROJECT CONDITIONS
   A. Service Conditions: NEMA PB1, usual service conditions.

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PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Acceptable Manufacturers:
      1. Cam Style Docking Receptacles:
         a. Eaton Crouse-Hinds
         b. Hubbell Wiring Device-Kellems

2.2 CAM STYLE DOCKING Receptacles
   A. Mounting: Within Switchgear enclosure.
   B. Listings: UL 1008.
   C. Voltage: 480/277 3 phase, 5 wire.
   D. Amperage: As shown on Drawings.
   E. Terminations:
      1. Generator:
         a. Phase and Neutral: 400A color coded cam style male connectors each of quantity
            to meet amperage rating.
         b. Ground: Green cam style male connectors.
      2. Generator Load: Mechanical compression types suitable for copper or aluminum 75
         degrees C cable meeting amperage rating.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine elements and surfaces to receive Generator Docking Receptacles for compliance with
      installation tolerances and other conditions affecting performance.
   B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
   A. Install generator docking receptacles as shown on Drawings.
   B. Maintain minimum clearances and workspace at equipment according to manufacturer’s written
      instructions and NFPA 70.

3.3 IDENTIFICATION
   A. Identify field installed conductors, interconnecting wiring, and components; provide warning signs
      as specified in Division 26 Section "Electrical Identification."

3.4 TERMINATIONS
   A. Connections: As indicated. Tighten connections to comply with tightening torques specified in
      UL 486A and 486B.

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applicable and current when publishing project specifications.
3.5 GROUNDING
A. Ground equipment to main electrical ground bus indicated. Provide minimum 5-ohm ground resistance at Generator Docking Devices location.

3.6 FIELD QUALITY CONTROL
A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each generator docking device bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.
B. Inspection and Tests
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS Sections for Switchboard components, "System Functional Tests", and "Thermographic Survey" requirements and the following additional requirements.
      a. Test generator docking device under load.
      b. Follow-up thermographic survey shall not be required.
      c. Prepare test and inspection reports.

3.7 CLEANING
A. On completion of installation, inspect interior. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.8 DEMONSTRATION
A. Train Owner's maintenance personnel to adjust, operate, and maintain generator docking devices, and accessories. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 262333
PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes service and distribution switchboards rated 600 V and less.

1.2 DEFINITIONS
   A. EMI: Electromagnetic interference.
   B. GFCI: Ground fault circuit interrupter.
   C. RFI: Radio frequency interference.
   D. RMS: Root mean square.
   E. SPDT: Single pole, double throw.

1.3 COORDINATION
   A. Coordinate layout and installation of switchboards and components with other construction that penetrates ceilings or is supported by them, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
   B. Coordinate size and location of concrete bases. Cast anchor bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.4 SUBMITTALS
   A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.5 ACTION SUBMITTALS
   A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground fault protector, accessory, and component indicated. Include dimensions and manufacturers’ technical data on features, performance, electrical characteristics, ratings, and finishes.
   B. Shop Drawings: For each switchboard and related equipment.
      1. Layout Drawings: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
         a. Enclosure types and details for types other than NEMA 250, Type 1.
         b. Bus configuration, current, and voltage ratings.
         c. Short circuit current rating of switchboards and overcurrent protective devices.
         d. Descriptive documentation of optional barriers specified for electrical insulation and isolation.
         e. Utility company's metering provisions with indication of approval by utility company.
         f. Mimic bus diagram.
         g. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
2. Wiring Diagrams: Power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Routine maintenance requirements for switchboards and all installed components.
   2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   3. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
   2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
   3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   5. Fuses for Fused Power Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   6. Touch-up Paint: Three half pints.

1.9 QUALITY ASSURANCE

A. Source Limitations: Obtain switchboards through one source from a single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
   1. Assembly Selection: The Drawings indicate sizes, profiles, and dimensional requirements of assembly equipment. Equipment having equal performance characteristics and complying with indicated maximum dimensions and profiles may be considered, provided deviations do not change the design concept intended performance, or code/future extension provision clearances. The burden of proof of equality is on the proposer a minimum of 10 days prior to bid.

C. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
   2. General Electrical Field Quality Control.

1.10 DELIVERY, STORAGE, AND HANDLING
A. Deliver in sections or lengths that can be moved past obstructions in delivery path.
B. Store indoors in clean dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.
C. Handle switchboards according to NEMA PB 2.1 and NECA 400.

1.11 FIELD CONDITIONS
A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
B. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
   1. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
C. Service Conditions: NEMA PB 2, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet (2000 m).
D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Construction Manager and Owner no fewer than fourteen (14) days in advance of proposed interruption of electric service.
   2. Indicate method of providing temporary electric service.
   3. Do not proceed with interruption of electric service without Construction Manager's and Owner's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers:
   1. Basis of Design: Square D; Schneider Electric
   2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.2 REGULATORY REQUIREMENTS
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
B. Comply with NEMA PB 2, "Deadfront Distribution Switchboards."
C. Comply with NFPA 70.
D. Comply with UL 891.
2.3 SWITCHBOARDS DESIGN CRITERIA

A. Front and Rear Accessible Switchboard: Front and rear aligned, with features as follows:
   1. Main Devices: Fixed, individually mounted.
   2. Branch Devices: Panel or fixed, individually mounted.

B. Nominal System Voltage: As scheduled on Drawings.

C. Main Bus Continuous Ampere Rating: As scheduled on Drawings.

D. Enclosure: Steel, NEMA 250, Type 1 or 3R, as indicated on Drawings.

E. Enclosure Finish for Outdoor Units: Factory applied finish in manufacturer's standard color, undersurfaces treated with corrosion-resistant undercoating.

F. Enclosure Finish for Indoor Units: Factory applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

G. Infrared (IR) View Panes: IR transmittance lens secured and sealed to assembly enclosure to allow inspection of electrical transmission components without elevated levels of Personal Protective Equipment (PPE). Locate view panels on [front] [and] [back] of enclosure to allow use of cameras with 2X to 3X horizontal and 1.5X to 2X vertical distance to target with a maximum angle of incidence of 30 degrees to view all 70 volt cable, busbar, and protective device connections within the assembly. Label each window by number, instructions for use, lens material, window transmission rates, and target components; location by clock face method; and baseline emissivity (e.g. "Busbar Connection: 2 o'clock: E = 0.95").

H. Barriers: Between adjacent switchboard sections.

I. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

J. Utility Metering Compartment: Where indicated on drawings provide a barrier compartment and section complying with utility company's requirements; hinged sealable door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

K. Customer Metering Compartment: Where indicated on drawings provide a separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks.

L. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

M. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchboard.

N. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

O. Pull Box on Top of Switchboard:
   1. When provided, ensure adequate ventilation to maintain temperature in pull box within same limits as switchboard.
   2. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
3. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
4. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

P. Buses and Connections: Three phase, four wire, unless otherwise scheduled on Drawings.
1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity or tin plated, high strength, electrical grade aluminum alloy.
   a. If bus is aluminum, use copper- or tin plated aluminum for circuit-breaker line connections.
   b. If bus is copper, use copper for feeder circuit breaker line connections.
2. Load Terminals: Insulated, rigidly braced, silver plated, copper runback bus extensions equipped with pressure connectors for outgoing circuit conductors. Provide load terminals for future circuit breaker positions at full ampere rating of circuit-breaker position.
3. Ground Bus: 1/4-by-2-inch- (6-by-50-mm-) minimum-size, hard drawn copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
4. Contact Surfaces of Buses: Silver plated.
5. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity for entire length of switchboard’s main and distribution sections. Provide for future extensions from both ends.
6. Disconnect Links:
   a. Isolate neutral bus from incoming neutral conductors.
   b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
7. Neutral Buses: 100 percent of the ampacity of phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus are braced.
8. Fire Pump Tap: Where indicated provide fire pump tap section in a separate barriered compartment on the line side of the main disconnect(s) and associated bus and tap lugs to feed the fire pump.

2.4 OVERCURRENT PROTECTIVE DEVICES (OCPDs)
A. Comply with requirements of Division 26 Section "Protective Devices" for types of OCPDs shown on Drawings. Provide indicated features, ratings, characteristics, and settings.
B. Future Devices: Where provision for future overcurrent protective devices or space is indicated, equip compartments with mounting brackets, supports, bus connections, and necessary appurtenances, designed for the OCPD types and ampere ratings indicated for future installation of devices.
   1. Bus space for future circuit breakers shall not be less than the 25% of the initial installed number of branch circuit breakers. Bus shall extend the full height of the section mounting space.

2.5 INSTRUMENTATION
A. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:
1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
3. Control Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kV.
4. Current Transformers for Neutral and Ground Fault Current Sensing: Connect secondaries to ground overcurrent relays to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker ground-fault protection.

B. Multifunction Digital Metering Monitor: Microprocessor based unit suitable for three or four wire systems and with the following features:
   1. Switch selectable digital display of the following values with maximum accuracy tolerances as indicated:
      a. Phase Currents, Each Phase: Plus or minus 1 percent.
      b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
      c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
      d. Megawatts: Plus or minus 2 percent.
      e. Megavars: Plus or minus 2 percent.
      f. Power Factor: Plus or minus 2 percent.
      g. Frequency: Plus or minus 0.5 percent.
      h. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from 5 to 60 minutes.
      i. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent. Accumulated values unaffected by power outages up to 72 hours.
   2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
   3. Zone Selective Interlocking (ZSI): Where indicated on drawings provide assembly integrated microprocessor based system per Division 26 Section "Protective Devices."

2.6 RATINGS
   A. Provide nominal system voltage, continuous main bus amperage, and short-circuit current ratings as shown on Drawings. Series ratings of protective devices is not acceptable.

2.7 ZERO VOLTAGE VERIFICATION SYSTEM
   A. General: Assembly integrated voltage test system with the following features:
   B. Function:
      1. Voltage indicating lights and test ports. This theoretically allows assembly maintenance or troubleshooting to be more safely performed by allowing qualified personnel to verify that equipment is deenergized.
   C. Voltage Ports:
      1. Dedicated ports located on front of assembly.
   D. Make: Grace Engineered Products Inc. – VTS Series.

2.8 ACCESSORY COMPONENTS AND FEATURES
   A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
B. Furnish portable test set to test functions of solid-state trip devices without removal from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

C. Spare Fuse Cabinet: Suitably identified, wall mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

2.9 IDENTIFICATION
A. General: Refer to Division 26 Section "Electrical Identification."

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. Install switchboards and accessories according to NEMA PB 2.1 and NECA 40.
B. Install switchboards on concrete bases.
   1. Anchor switchboards to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 26 Sections "Hangers and Supports" and "Vibration Controls."
   2. Bolt switchboards to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.
C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on end of the switchboards or as shown on Drawings.
F. Install overcurrent protective devices, surge protective devices, and instrumentation.
   1. Set field adjustable switches and circuit-breaker trip ranges.
G. Install spare fuse cabinet.

3.3 IDENTIFICATION
A. Provide as specified in Division 26 Section "Electrical Identification."

3.4 GROUNDING
A. Connections: As indicated. Tighten connections to comply with tightening torques specified in UL 486A and 486B.
B. Ground equipment to main electrical ground bus indicated. Provide minimum 5-ohm ground resistance at switchboard location.

3.5 FIELD QUALITY CONTROL

A. Protection:
   1. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

B. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Inspection and Tests:
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS Sections for associated switchboard components, "System Functional Tests", and "Thermographic Survey" requirements and the following additional requirements.
      a. Follow-up thermographic survey shall not be required.
      b. Prepare test and inspection reports.

D. Adjusting:
   1. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
   2. Set field-adjustable circuit-breaker trip ranges as specified in Section "Overcurrent Protective Device Coordination Study."

E. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make appropriate circuit changes.
   1. Measure as directed during period of normal system loading.
   2. Perform load balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24 hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
   3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
   4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 CLEANING

A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.7 DEMONSTRATION

A. Engage a factory authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 262413
PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes lighting and power panelboards and associated auxiliary equipment rated 600 volt or less.

1.2 DEFINITIONS
A. Lighting and Appliance Panelboard: A panelboard with thermal magnetic circuit breaker branches, bolt-in type only, designed for heavy commercial use, operating at 600 V and below, 3-phase versions, equipped as either surface or flush mounting. Panelboard shall have more than 10 percent of its overcurrent devices rated 30 amperes or less for which neutral connections are provided.

B. Distribution Power Panelboard: A panelboard with thermal magnetic circuit breakers or fusible switches, bolt-in type, designed for heavy commercial use, operating at 600 V and below, 3-phase version, equipped as surface mounting with cabled connections between sections. Panelboard shall have less than 10 percent of its concurrent devices rated 30 amperes or less for which neutral connections are provided.

C. Surge Protection Device (SPD): A device to reduce the effect of voltage spikes to sensitive electronic equipment by shunting these disturbances to earth ground.

D. Overcurrent Protective Device (OCPD): A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic 26 Division Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: For each type of panelboard, overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings:
   1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      a. Enclosure types and details for types other than NEMA 250, Type 1.
      b. Bus configuration, current, and voltage ratings.
      c. Short-circuit current rating of panelboards and overcurrent protective devices. Series rated protective devices are not acceptable.
      d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   2. Wiring diagrams detailing control wiring and differentiating between manufacturer-installed and field-installed wiring.
3. Panelboard SPD data, circuit breaker disconnects, and dimensioned room layouts ensuring proper NEC clearances and coordination.
   a. Installation instructions shall be reviewed to determine whether the system requires an external overcurrent device in order to maintain the systems UL 1449 3rd Edition listing.
   b. A UL 1449 3rd Edition stipulation is required for all submittals. The stipulation will verify the use of additional fusing via manufacturer’s signature.

1.5 INFORMATIONAL SUBMITTALS
   A. Qualification Data: For testing agency.
   B. Field quality control test reports including the following:
      1. Test procedures used.
      2. Test results that comply with requirements.
      3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.6 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section “Operation and Maintenance Data,” include the following:
      1. Manufacturer’s written instructions for testing and adjusting overcurrent protective devices.
      2. Include copy of typed directions depicting branch circuit loads.
   B. Record Documents:
      1. Panelboard Schedules: Created in Froedtert Hospital standard spreadsheet format and printed for installation in panelboards. Refer to samples at the end of this specification.
      2. Deliver electronic files to Owner in PDF and Excel format.
      3. Refer to sample at the end of this section.
      4. Provide color coded graphical plan for each panelboard indicating the area served by the panelboard.

1.7 MAINTENANCE MATERIAL SUBMITTALS
   A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      1. Keys: Two (2) spares for each type of panelboard cabinet lock.

1.8 QUALITY ASSURANCE
   A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories through one source from a single manufacturer.
   B. Product Options: Drawings indicate size, profiles, and dimensional requirements of panelboards and are based on the specific system indicated. Refer to Division 01 Section “Product Requirements.”
   C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
   2. General Electrical Field Quality Control.


1.9 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
   1. Ambient Temperature: Not exceeding 104 deg F (40 deg C).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet (2000 m).

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Construction Manager and Owner no fewer than fourteen (14) days in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without Construction Manager's and Owner's written permission.

1.10 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers:
   1. Basis of Design: Square D; Schneider Electric.
   2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.
2.2 PANELBOARDS, GENERAL REQUIREMENTS

A. Overcurrent Protective Devices (OCPDs): Provide type, rating, and features as shown on Drawings. Comply with Division 26 Section "Protective Devices," with OCPDs adapted to panelboard installation. Tandem circuit breakers shall not be used. Multipole breakers shall have common trip.

B. Supports and Bracing for Buses: Adequate strength of all panelboard components, including OCPD's, for short circuit current ratings as shown on Drawings. The minimum ratings shall be 10,000 AIC for 120/208 volt equipment and 14,000 AIC for 277/480 volt equipment. Series ratings of protective devices shall not be acceptable.

C. Enclosures: Cabinets, flush or surface mounted as shown on Drawings. NEMA Type 1 enclosure, except where the following enclosure requirements are shown on Drawings. Backboxes shall be made from galvanized steel. Where feeder cables supplying the mains of a panel are carried through its box to supply other electrical equipment, the box shall be sized to include the additional required wiring space. Provide at least four interior mounting studs with adjustable nuts.

D. Hinged Front Cover: Entire front trim hinged to box with standard door within hinged trim cover. (Exception: Elevator Room fused switch panelboards).

E. Typed directory card completely filled out including "SPARE" and "SPACE" loads.

F. Bus: Tin-plated Aluminum or Copper

G. Main and Neutral Lugs: Mechanical type.

H. Main Circuit Breaker (when scheduled): Mounted physically separate from branch breaker lineups (not in same row) to allow for full branch circuit pole quantity.

I. Branch Circuit Devices: Arranged for double row construction.

J. Equipment Ground Bus: Adequate for feeder and branch circuit equipment ground conductors. Bond to box with bolted or welded connection.

K. Gutter: Generally, conform to UL 61.

L. Extra Gutter Space: Arrangement as shown on Drawings or as required for installation.

M. Auxiliary Gutter: Conform to UL 870, "Wireways, Auxiliary Gutters, and Associated Fittings."

N. Provision for Future Devices: Equip with mounting brackets, bus connections and extensions, and necessary appurtenances, for the OCPD ampere ratings shown on Drawing schedules for future installation of devices.
   1. Bus space for future circuit breakers shall not be less than the 25% of the initial installed number of branch circuit breakers. Bus shall extend the full height of the section mounting space.

O. Special Features: Provide the following features for panelboards as scheduled and or shown on Drawings or as required to meet NEC:
   1. Isolated Equipment Ground Bus: Adequate for branch circuit equipment ground conductors; insulated from box.
2. Shunt Trip Control Power Source: Shunt trips where shown on Drawings shall be 120 volt AC. Provide a 120 volt power supply from the main bus with a primary fuse protected, control power transformer, with terminals and wiring for the shunt trip connection to remote pushbutton station(s). Where specified for "emergency" shut-down, install pushbutton on the panel trim. Access to interior shall be without disturbing pushbutton and shall allow for wiring disconnection from pushbutton.

3. Gutter Barrier: Arranged to isolate section of gutter as shown on Drawings.

4. Subfeed (Double Lugs): OCPD or lug provisions sized to accommodate feeders shown on Drawings. Provide subfeed lugs for all multi section panelboards. Field install all required cross connection cables.

5. Feed-Through Lugs: Sized to accommodate feeders shown on Drawings.

6. Metering: Manufacturers standard devices as shown on Drawings (compatible with metering equipment per Division 26 Section "Electric Power Management Systems.")

7. Molded Case Switch: Sized to accommodate feeder lugs shown on Drawings.

P. Plug-in type load center type panelboards shall not be used.

2.3 LIGHTING AND APPLIANCE PANELBOARDS

A. General: Conform to above article "Panelboards, General Requirements" except as follows:

1. Circuit Breakers for Switching Lights at Panelboards: Indicated type SWD.
2. Circuit Breakers for Equipment Marked HACR Type: Indicated HACR type.
3. Interiors: Provide physical means to prevent installation of more OCPDs than the quantity for which the enclosure was listed.
4. Main, Neutral, and Ground Lugs and Buses: Have mechanical connectors for conductors.
5. Branch OCPDs: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
6. Doors: In panel front, with concealed hinges. Secure with flush catch and cylindrical tumbler lock, all keyed alike. The flush lock shall not protrude beyond the front of the door.

2.4 POWER DISTRIBUTION PANELBOARDS

A. Doors: The flush lock shall not protrude beyond the front of the door. Doors over 48 inches high hinged, and shall be provided with, built-in locks, and three point latch (top, bottom and center).

B. Branch-Circuit Breakers: Where OCPDs are shown on Drawings to be circuit breakers, use bolt-on breakers where available. Plug-in type circuit breakers may be used where fastened in place and require mechanical release for removal.

C. Install metering equipment as shown on Drawings and as per Division 26 Section "Electric Power Management Systems."

2.5 ZERO VOLTAGE VERIFICATION SYSTEM

A. General: Assembly integrated voltage test system with the following features:

B. Function:

1. Voltage indicating lights and test ports. This theoretically allows assembly maintenance or troubleshooting to be more safely performed by allowing qualified personnel to verify that equipment is deenergized.

C. Voltage Ports:

1. Dedicated ports located on front of assembly.

D. Make: Grace Engineered Products Inc. – VTS Series.
2.6 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items as required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: Arranged to permit testing of functions of solid-state trip devices without removal from panelboard.

C. Branch Circuit Terminal Cabinet: Locate a junction/pull box above each panelboard and terminate all branch circuits on DIN rail mounted insulated screw terminal blocks. Connect the cabinet to the panelboard box via two short conduits aligned with each side wire gutter of the panelboard. Provide equipment ground terminal bar with enough openings for each pole of the panelboard and extend the feeder equipment grounding conductor to this bar from the panelboard ground bar. Neutral conductors shall be terminated on insulated terminal blocks separate from the phase conductor terminal blocks.

2.7 IDENTIFICATION

A. General: Refer to Division 26 Section "Electrical Identification,” for labeling materials and methods.

B. Manufacturer’s Nameplate Information:
   1. Voltage.
   2. Phase.
   3. Ampacity.
   4. Manufacturer.
   5. A.I.C. Symmetrical.
   6. UL Listing.
   7. Service Entrance Label (as applicable).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Comply with mounting and anchoring requirements specified in Division 26 Section "Hangers and Supports" and "Vibration Controls."

C. Mount top of trim 78 inches above finished floor, unless otherwise indicated.

D. Mount large distribution and column type panelboards minimum 6-inches above floor. When top and bottom dimensional requirements cannot be met, install on concrete bases.
   1. For distribution panelboards on concrete bases, anchor according to manufacturer’s written instructions, seismic codes at Project, and requirements in Division 26 Sections "Hangers and Supports" and "Vibration Controls".

E. Maintain minimum clearances and workspace at equipment according to manufacturer’s written instructions and NFPA 70.

F. Mount plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

G. Install overcurrent protective devices and controllers.
   1. Set field-adjustable switches and circuit-breaker trip ranges.
H. Install filler plates in unused spaces and plug any unused, open cabinet knockouts.

I. Install breaker handle clips in on position at breakers servicing fire alarm equipment.

J. Stub four (4) 1-inch empty conduits from recessed panelboards into accessible ceiling space or space designated to be ceiling space in the future.

K. For each 120/208V branch circuit panelboard, provide eight (8) spare circuits to a junction box located above the panel to allow for future extension without need for a shutdown. Wire shall be safely terminated and labeled with circuit number and identified as “Spare/Future.” The associated protective device(s) shall be turned off and appropriately identified as “Spare/Future” and to include a description of where the existing wires are terminated.

L. When a home run to an existing panelboard is shown, compatible circuit protective of the indicated ratings shall be provided when they are not in the existing panel. Whenever circuits are removed from existing panels, the associated conduit and wire shall be removed back to a junction box above the panelboard. Wire shall be safely terminated and labeled with circuit number and identified as “Spare/Future”. The associated protective device(s) shall be turned off and appropriately identified as “Spare/Future” and to include a description of where the existing wires are terminated. Adjust directories accordingly.

M. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Electrical Identification."

   1. Provide "Fire Alarm System" component identification label at breakers servicing fire alarm equipment.

B. Create a typed directory to indicate installed circuit loads. Label circuit locations with room numbers (not occupancy) and spares. Obtain written approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

3.3 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding."

B. Connect wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.

   2. Test continuity of each circuit.

B. Inspection and Tests:

   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing"; ANSI/NETA ATS Sections for associated panelboard components, "System Functional Tests", and "Thermographic Survey" requirements and the following additional requirements.

      a. Follow-up thermographic survey shall not be required.

      b. Prepare test and inspection reports.
C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make appropriate circuit changes with Froedtert approval.

1. Measure as directed during period of normal system loading.
2. Perform load balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24 hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.5 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.
3.6 SAMPLE PANEL SCHEDULES

A. 120/208V Panel Schedule:

<table>
<thead>
<tr>
<th>Building</th>
<th>Location</th>
<th>Room Number</th>
<th>Circuit #</th>
<th>Load</th>
<th>Fed From Panel</th>
<th>Fed From Room</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1, 3, 5</td>
<td>Panel E3123</td>
<td>A</td>
<td>B, 2, 4, 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>Receptacles West and North Walls</td>
<td>A</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9</td>
<td>Receptacle East Wall</td>
<td>D</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td>Receptacles</td>
<td>B</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>13</td>
<td>Rooms 2925, 2921, &amp; 2922</td>
<td>C</td>
<td>14</td>
</tr>
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Revision Date: As Project.
### 277/480V Panel Schedule:

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**PANELBOARDS**

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### C. Distribution Panel Schedule:

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PANELBOARDS

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SECTION 262485 - CONTACTORS

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes contacts rated 600V and under. It includes the following items:
      1. General purpose contactors.
      2. Lighting contactors.

1.2 QUALITY ASSURANCE
   A. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems.
   B. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies.

1.3 SUBMITTALS
   A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.4 ACTION SUBMITTALS
   A. Product Data: Include dimensions, size, voltage ratings and current ratings.

1.5 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Manuals:
      1. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements.
      2. Record Documents:
         1. Submit under provisions of Division 01.
         2. Accurately record actual locations of each contactor and indicated circuits controlled.

1.6 OPERATION AND MAINTENANCE DATA
   A. Submit under provisions of Division 01 and required of Division 26 Section "Basic Division 26 Requirements."
   B. Maintenance Data: Include instructions for replacing and maintaining coil and contacts.

1.7 QUALITY ASSURANCE
   A. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
      2. General Electrical Field Quality Control.
1.8 REGULATORY REQUIREMENTS
   A. Conform to requirements of ANSI/NFPA 70.
   B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

PART 2 - PRODUCTS

2.1 GENERAL PURPOSE CONTACTORS
   A. Manufacturers:
      2. Square D Co.
   B. General Purpose Contactors:
      1. Description: NEMA ICS 2, AC general purpose magnetic mechanically held contactor.
      2. Coil Voltage: AS scheduled.
      3. Poles: As scheduled.
      4. Size: As scheduled.
      5. Enclosure: ANSI/NEMA ICS 6, Type 1.
      6. Required Accessories:
         a. Selector Switch on Front Cover: ON/OFF/AUTOMATIC.
         b. Auxiliary Contacts: One normally open and one normally closed.
         c. Fused Control Transformer.

2.2 LIGHTING CONTACTORS
   A. Manufacturers:
      2. Square D Co.
   B. Lighting Contactors:
      1. Description: NEMA ICS 2, magnetic lighting contactor.
      2. Configuration: Mechanically held, 2 wire control.
      3. Coil Voltage: 24V unless scheduled otherwise.
      4. Poles: As scheduled.
      5. Contact Rating: As scheduled.
      7. Required Accessories:
         a. Selector Switch On Front Cover: ON/OFF/AUTOMATIC.
         b. Auxiliary Contacts: One normally open and one normally closed.
         c. Fused Control Transformer.

2.3 ACCESSORIES
   A. Pushbuttons and Selector Switches: NEMA ICS2, heavy duty type.
   B. Auxiliary Contacts: NEMA ICS 2, Class A300.
   C. Identification label per Division 26 Section "Electrical Identification."
PART 3 - EXECUTION

3.1 INSTALLATION
   A. Install in accordance with manufacturer's instructions.
   B. Coordination:
      1. Provide auxiliary relays, contacts, control voltage transformers, etc., to coordinate operations with remote control devices shown on Drawings.
      2. Coordinate contactor type and ratings for specific application.

3.2 COORDINATION
   A. Coordinate together with equipment suppliers and other Divisions, their equipment operational voltages and controls for proper operation of contactors. Provide any necessary auxiliary equipment for system interfaces.

3.3 FIELD QUALITY CONTROL
   A. Inspection and Tests:
      1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS "Switches, Air, Low-Voltage", "System Functional Tests", and "Thermographic Survey" requirements and the following additional requirements.
         a. Follow-up thermographic survey shall not be required.
         b. Prepare test and inspection reports.

END OF SECTION 262485
SECTION 262500 - BUSWAY

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Plug-in busway assemblies.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.3 ACTION SUBMITTALS

A. Product Data:
   1. For each type of busway assembly and plug-in device:
   2. Show fabrication and installation details for enclosed busway assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.
   3. Show fittings, materials, fabrication, and installation methods for listed fire-stop barriers.
   4. Indicate required clearances, method of field assembly, and location and size of each field connection.

B. Shop Drawings:
   1. Layout Drawings: Floor plans and sections, drawn to scale. Include scaled bus-assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Show the following:
      a. Vertical and horizontal enclosed bus-assembly runs, offsets, and transitions.
      b. Clearances for access above and to the side of enclosed bus assemblies.
      c. Vertical elevation of enclosed bus assemblies above the floor or bottom of structure.
      d. Support locations, type of support, and weight on each support.
      e. Location of adjacent construction elements including light fixtures, HVAC and plumbing equipment, fire sprinklers and piping, signal and control devices, and other equipment.
   2. Detail connections to switchgear, switchboards, transformers, and panelboards.

1.4 INFORMATIONAL SUBMITTALS

A. None required.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed bus assemblies to include in emergency, operation, and maintenance manuals.
QUALITY ASSURANCE
A. Source Limitations: Obtain enclosed bus assemblies and plug-in devices through one source from a single manufacturer.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
C. Comply with NFPA 70.

DELIVERY, STORAGE, AND HANDLING
A. Deliver, store, and handle enclosed bus assemblies according to NEMA BU 1.1, "General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 Volts or Less."

PROJECT CONDITIONS
A. Derate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature over 104 deg F (40 deg C) not exceeding 122 deg F (50 deg C).

COORDINATION
A. Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
B. Coordinate size and location of concrete curbs around openings for vertical bus. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

MANUFACTURERS
A. Manufacturers:
   1. Square D; Schneider Electric
   2. Legrand; Starline
   3. Acceptable Equivalents/Manufacturers as approved by Owner, submit as substitution request per Division 1.

BUSWAYS, GENERAL
A. Busway System: Plug-in type, complete with manufacturer's recommended fittings and accessories as shown on Drawings and as required for a complete, functioning installation.
B. Busway features shall include conductor bus bars, electrical insulators, enclosures, flanges, elbows, offsets, tees, cable tap boxes, weatherheads, transformer connections, power take-off sections, reducers, expansion joints, end closures, supports, and other components and accessories needed to form complete systems. Phase balancers shall be utilized for busways with multiple bus bars per phase.
C. Ratings: Three phase with voltage and current ratings and requirements for neutral and ground buses as shown on Drawings. Minimum short circuit ratings of busway shall be as shown on Drawings.
   1. Neutral bus shall be 100 percent of phase buses.

D. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.

E. Bus Materials: Current-carrying copper or aluminum conductors.

F. Bus Bars: Plated at electrical contact surfaces and insulated over entire length, except at contact surfaces, with 130 deg C class insulation.

G. Ground:
   1. 50 percent capacity integral with housing.
   2. 50 percent capacity internal bus bars of material matching bus material.

H. Joint Construction – One or two bolt type requiring access to one side only for tightening. Removal of any section without disturbing adjacent sections shall be possible. Belleville washers shall be provided to give constant pressure over contact area.

I. Impedance limited to that which results in voltage drop line to line less than 2.2 volt per 100 feet at power factor which produces maximum voltage drop using an evenly distributed load.

J. Fittings and Accessories: Manufacturer’s standard.

K. Mounting: Arranged flat, edgewise, or vertically without derating.

2.3 PLUG-IN BUSWAY ASSEMBLIES

A. Enclosure: Steel, with manufacturer’s standard finish, plug-in openings 24 inches (610 mm) o.c., and hinged covers over unused openings.

2.4 PLUG-IN DEVICES

A. General: Compatible with the connected busway and of types as shown on Drawings. Plug-in devices shall be equipped with spring reinforced contact fingers arranged so they will not make contact with bus bars during plug insertion until the device housing is positively grounded to the busway. Plug-in devices shall lock in position mechanically and make positive grounding contact in addition to the power connection when in the fully inserted position. A safety interlock on bus plugs having "on" and "off" positions to prevent insertion or removal when they are in the "on" position. Bus plugs for use with busway having an integral or internal ground bus shall be equipped with a grounding finger arranged to make positive contact with the ground bus before phase connections make contact when inserting the plug. Mounting hardware shall be captive on bus plug housing. The grounded method shall be such that it cannot be defeated by future painting of the busway housing. The plug-in units shall be equipped with internal barriers to prevent accidental contact of fish tape and conductors with live parts on the line side of the protective device during time of wire pulling. Covers of all plug-in units shall have "releasable" type interlocks to prevent the cover from being opened while the switch is in the on position. The plugs shall be provided with means for padlocking the switch in the off position. Plug in units shall be equipped with means for direct positioning of the busway before the plug-in jaws make contact. Operating handles shall be easily moved to either side of enclosure for ease of operation. Plug assist shall be furnished on all units.
B. Circuit Breaker Plugs: Capable of operation from the floor. Circuit breaker shall comply with NEMA AB 1, “Molded Case Circuit Breakers” with ratings and characteristics as shown on Drawings and per Division 26 Section “Protective Devices.” Breaker shall have defeatable interlock with bus plug door.

C. Fusible Switch Plugs: Quick make, quick break switch capable of operation from the floor, and complying with NEMA KS 1, “Enclosed Switches.” Switch ratings and fuse characteristics and ratings shall be as shown on Drawings and per Division 26 Section “Protective Devices”

2.5 FINISHES

A. Indoor Busway: Manufacturer’s standard finish over corrosion resistant pretreatment.

2.6 SUPPORTS AND ACCESSORIES

A. General: As recommended by busway manufacturer and conforming to Division 26 Sections "Hangers and Supports“ and "Vibration Control."

B. Spring Mounted Vertical Riser Supports: Adjustable for leveling and spring tension and arranged to permit relative movement between floor and busway.

C. Rigid Floor Supports: Adjustable for leveling.

D. Expansion Section: Capacity and conductor provisions same as adjacent busway section. Arranged to absorb expansion and contraction of bus bars and housing.

E. Fasteners to connect busway supports to the building structure as follows:
   1. Expansion Anchors: Carbon steel wedge or sleeve type.
   2. Toggle Bolts: All steel springhead type.

F. Hook Switch Poles: Provide plug-in unit poles to switch devices higher than 5'-0.” Include wall hanger hardware for pole.

2.7 FIRESTOPPING

A. General: Materials UL listed and labeled and Factory Mutual approved for fire ratings consistent with penetrated barriers and in accordance with Division 07 Section “Penetration Firestopping.”

B. Wall and Floor Flanges: Sheet steel, 12-gage minimum close fitting to busway and arranged to close the wall or floor opening at the busway penetration.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.

B. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer’s recommended distance between fittings.

C. Construct rated fire-stop assemblies where bus assemblies penetrate fire-rated elements such as walls, floors, and ceilings. Seal around penetrations according to Division 07 Section “Penetration Firestopping”.

BUSWAY 262500 - 4

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D. Install a concrete base curb at least 4 inches (100 mm) high around bus-assembly floor penetrations according to Division 26 Section "Hangers and Supports".

E. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.

F. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.

G. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

H. Mount hook switch poles on hanger in each electrical room having busway plug-in inserts.

I. Provide color coded labeling on busway enclosure similar to the requirements for raceway according to Division 26 section “Electrical Identification”.

3.2 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding."

B. Connect wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Inspection and Tests:
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS "Metal-Enclosed Busways", "System Functional Tests", and "Thermographic Survey" requirements and the following additional requirements.
      a. Follow-up thermographic survey shall not be required.
      b. Prepare test and inspection reports.

3.4 ADJUSTING

A. Set field-adjustable, circuit-breaker trip ranges and overload relay trip settings as indicated.

3.5 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.6 PROTECTION

A. Provide final protection to ensure that moisture does not enter bus assembly.

END OF SECTION 262500
SECTION 262713 - ELECTRICITY METERING

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes equipment for owner and utility company's electricity metering.

1.2 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.3 ACTION SUBMITTALS
A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Describe electrical characteristics, features, and operating sequences, both automatic and manual.
B. Shop Drawings:
   1. Layout Drawings: Dimensioned plans and sections or elevation layouts.
   2. Wiring Diagrams: Power, signal, and control wiring specific to this Project. Identify terminals and wiring designations and color codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features.

1.4 INFORMATIONAL SUBMITTALS
A. None required.

1.5 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For electricity-metering equipment to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE
A. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
   2. General Electrical Field Quality Control.
1.7 PROJECT CONDITIONS
A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Construction Manager and Owner no fewer than fourteen (14) days in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without Construction Manager’s or Owner’s written permission.

1.8 COORDINATION
A. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:
   1. Comply with requirements of utilities providing electrical power and communication services.
   2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 REGULATORY REQUIREMENTS
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

2.3 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY
A. Current-Transformer Cabinets: Comply with requirements of electrical power utility company.
B. Meter Sockets: Comply with requirements of electrical power utility company.
   1. Manufacturers:
      a. Basis of Design: Square D; Schneider Electric
      b. Acceptable Equivalents/Manufacturers as approved by Owner, submit as substitution request per Division 1.
   2. Housing: NEMA 250, Type 1 or 3R enclosure as indicated.
   3. Voltage: As indicated on drawings.
   4. Minimum Short-Circuit Rating: As indicated on drawings but not less than 10,000 amperes symmetrical at rated voltage.
   5. Main Disconnect Device: Circuit breaker or fusible switch, as indicated.
   6. Meter Socket: Type as approved by utility company, with rating coordinated with indicated tenant feeder circuit rating.

ELECTRICITY METERING

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2.4 EQUIPMENT FOR ELECTRICITY METERING BY OWNER

A. Manufacturers:
   1. Basis of Design: Square D; Schneider Electric
   2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

B. Kilowatt-Hour/Demand Meter: Electronic meters, measuring electricity use and demand.
   1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
   2. Display: Digital liquid crystal, indicating accumulative kilowatt hours, current time and date, current demand, historic peak demand, and time and date of historic peak demand.
   3. Demand Signal Communication Interface: Match signal to remote building automation system input and arrange to convey the instantaneous, integrated, demand level measured by meter to provide data for processing and possible programmed demand control action by destination system.
   4. Programmable Contact Module: Unit shall have push-button switches and a display for setting the demand level at which an integral set of Form C contacts shall be operated to initiate indicated action.
   5. Enclosure: NEMA 250, Type 1 or 3R as indicated, with hasp for padlocking or sealing.
   6. Identification: Comply with Division 26 Section "Identification for Electrical Systems."
   7. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.
   8. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for ratings of circuits indicated for this application.
   9. Meter Accuracy: Nationally recognized testing laboratory certified to comply with ANSI C12.1.
   10. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Comply with equipment installation requirements in NECA 1.
   B. Install equipment for utility company metering. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

3.2 FIELD QUALITY CONTROL
   A. Inspection and Tests:
      1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS "Instrument Transformers", "Metering Devices", "System Functional Tests", and "Thermographic Survey" requirements and the following additional requirements.
         a. Follow-up thermographic survey shall not be required.
         b. Prepare test and inspection reports.

END OF SECTION 262713
SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY
A. This Section provides requirements and specification criteria for wiring devices, wiring device accessories, and wiring device assemblies including:
   1. AC Lighting Switches.
   2. Receptacles.
   3. Cord Style Plug Connectors.
   4. Wall Box Dimmers.
   5. Coverplates.

1.2 REFERENCES
A. Abbreviations and Definitions:
   1. Coverplate: Metallic or non-metallic plates providing a finished closure between wall, floor or ceiling construction, electrical outlet box provisions, and wiring devices.
   2. EMI: Electromagnetic Interference.
   3. GFCI: Ground-Fault Circuit Interrupter.
   4. Pigtail: Short lengths of conductors factory pre-wired to a modular, plug-in style connecting device, used for connecting plug-in style wiring devices to field supplied branch circuit conductors.
   5. RFI: Radio Frequency Interference.
   7. Wall Plates: Coverplate.

B. Reference Standards:
   1. Conform to execute, inspect and test, in accordance with code(s), standards, and governing rules and regulations of Federal, State, and Local governmental agencies having jurisdiction at the project locale.
   2. Other reference which apply to this section include the enforced editions of:
      a. NEMA - National Electrical Manufacturers Association:
         1) FB 11-83 (Reapproved 1989) Plugs, Receptacles, and Connectors of the Pin and Sleeve Type for Hazardous Locations
         2) WD 1-83 (Reapproved 1989) General Requirements for Wiring Devices
         3) WD 6-88 Wiring Device – Dimensional Requirements
      b. UL - Underwriters Laboratories:
         1) 486-91 (Rev. 95) Wire Connectors and Soldering Lugs for Use with Copper Conductors
      c. Fed. Spec. - Federal Specifications:
         1) WC-596 for receptacles
         2) WS-896 for switches
1.3 SUBMITTALS
   A. General: Submit in accordance with Conditions of Contract, Division 01 Specification Sections, and Division 26 Section "Basic Division 26 Requirements."

1.4 ACTION SUBMITTALS
   A. Product Data:
      1. Product data for each type of product specified.
      2. List of legends and description of materials and process used for premarking wall plates.
      3. Operation and Maintenance Data for wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 INFORMATIONAL SUBMITTALS
   A. Field quality control test reports.

1.6 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: Include manufacturers' packaging instructions, labels, operating manuals, etc.
   B. Test results, including electronic log of receptacle testing date in the format provided by the specified meter.

1.7 MAINTENANCE MATERIAL SUBMITTALS
   A. Furnish extra materials described in subparagraphs below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      1. Tamperproof Tools: Provide not less than two (2) screwdrivers, wrenches, or other tools, required for the installation and removal of tamperproof devices provided under this Section.

1.8 QUALITY ASSURANCE
   A. Source Limitations: Provide each type of wiring device and associated coverplates from a single manufacturer. Insofar as they are available, provide all wiring devices and associated coverplates from a single manufacturer.
   B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
      2. Underwriters Laboratories Inc. (U.L.):
         a. U.L. 20 General-Use Snap Switches
         b. U.L. 498 Electrical Attachment Plugs and Receptacles
         c. U.L. 894 Switches for Use in Hazardous (classified) Locations
         d. U.L. 943 Ground-Fault Circuit Interrupters
         e. U.L. 1010 Receptacle-Plug Combinations for Use in Hazardous (classified) Locations

WIRING DEVICES 262726 - 2
D. Comply with NEMA WD 1.
E. Comply with NFPA 70.
F. Comply with NFPA 99.

1.9 COORDINATION
A. Receptacles for Owner-Furnished Equipment: Verify and match Owner furnished equipment plug configurations.
   1. Cord and Plug Sets: Verify and match Owner furnished equipment requirements.

1.10 SEQUENCE AND SCHEDULING
A. Protect wiring devices if installed prior to painting.
B. Schedule installation of finish plates after the surface upon which they are installed has received final finish.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Source Limitations: Except as otherwise noted, specified, or required, provide each type of wiring device and associated accessories, coverplates, etc., from a single manufacturer.
B. Acceptable Manufacturers:
   2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.2 GENERAL REQUIREMENTS
A. Provide wiring devices, in types, characteristics, grades, finishes, colors, electrical ratings listed and labeled, etc., for applications indicated and in compliance with UL and other applicable ANSI and NEMA standards.
B. Wiring Device Face Colors:
   1. General – Except as otherwise noted, provide white device face color. Verify color selections with Architect.
   2. Wiring device face colors for special application devices, except as otherwise indicated, specified, or required, shall be as follows:
      a. Receptacles:
         1) Connected to NEC Article 517 Essential Electrical System – Red.
         2) Connected to NEC Article 700, 701, and 702 Emergency/Standby Systems – Red.
         3) Connected to UPS - Grey
      b. Switches (Toggle/Actuator Color):
         1) Connected to NEC Article 517 Essential Electrical System – Red.
         2) Connected to NEC Article 700, 701 and 702 Emergency/Standby Systems – Red.
3) Connected to UPS - Grey


D. Wall Box Dimmers: Solid state conforming to NEMA WD 1.


F. All receptacles shall be hospital grade except if submitted as a substitution request to the owner.

G. Ground-Fault Circuit Interrupter (GFCI) Receptacles:
   1. Unless noted otherwise, shall be duplex, 3-wire grounding non feed-thru type, Class A, Group 1, designed, built and tested per UL Standard 943.
   2. Shall be self-testing automatic monitoring type, designed and constructed to automatically monitor and periodically test themselves for their ability to detect a ground fault condition. Upon failure to detect a ground fault condition:
      a. Device shall automatically trip open, rendering the device "dead-front" (zero voltage or current present at the receptacle face contact points), and simultaneously open the circuit to downstream devices.
      b. Provide visual indication, at the device face indicating the device can no longer protect against ground fault conditions (end-of-life indication).

H. Cord Style Plug Connectors: 20 amperes, 125-volts, nylon body connectors, 3-wire, grounding, parallel blades, double wipe contact, with cord clamp, cord hole. Match NEMA configuration to mating plug. Arrange as shown on Drawings.

2.3 WIRING DEVICE PIGTAIL CONNECTOR FEATURE

A. Provide UL 2459 listed pigtail style modular connectors designed, fabricated, and tested for use with stranded branch circuit conductors may be provided to allow:
   1. Rough-in of pre-stripped six inch leads to a connector.
   2. Modular plug-in to the wiring device.
   3. Basis of Design:
      a. Hubbell - Snap Connect™.
      b. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.4 AC LIGHTING SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Standard toggle handle specification grade snap connected: (* Indicates single pole, double pole, 3-way or 4-way, as required.)
   1. 20 amp, 120-277 volt:

C. Lighted toggle style, 20 amp, 120-277 volt, specification grade, snap connected. (*Indicates single pole, double pole, 3-way or 4-way, as required.)
   1. Pilot Type – Red, translucent, polycarbonate toggle, lighted in the "ON" position.
2. Locator Type – White or ivory, translucent, polycarbonate toggle, lighted in the "OFF" position.
   a. Hubbell – SNAP122* IL Series.

2.5 WALL BOX DIMMERS
A. LED:
   1. 3-Wire Linear Slide Type:
      a. Shall be solid state electronic, electro-mechanical devices, with linear slide style actuator, suitable for use, and compatible with the procured 3-wire LED drivers.
         1) UP movement of actuator turns connected load ON.
         2) UP/DN linear slide movement of actuator raises/lowers lighting intensity.
         3) DN slide movement to lowest position turns connected load OFF.
      b. Shall be rated to control not less than the following dimmable LED lighting load:
         1) 16A @ 120VAC.
         2) 8A @ 277VAC.
      c. Provide as single pole or 3-way multi-location control devices as indicated.
      d. Shall be semi-flush, thin profile design, with no exposed heat sink fins, designed fabricated and tested for installation within a single gang electric box opening.
      e. Linear slide actuating device shall provide a positive mechanical air gap type branch circuit disconnecting means at the bottom travel OFF position.
      g. Actuator Finish/Color: Nylon/White other.
      h. Acceptable Manufacturers:
         1) Lutron Electronics, Inc. - "Nova-T" Series.
         2) Or equivalent.
   2. 0-10V Linear Slide Type:
      a. Shall be electronic, low voltage, solid state devices, with linear slide style dimming actuator, suitable for use and compatible with 0-10V LED drivers.
         1) UP/DN linear slide action raise/lower actuator.
         2) ON/OFF control shall be initiated by the device, via a remote, separately installed power supply/control unit with integral switching relay.
         3) Slide to lowest position shall initiate OFF command to separately installed power supply/control unit.
      b. Shall, in combination with the remote power supply/control unit switching relay, control not less than 16A of dimmable LED driver lighting load @ either 120 or 277VAC.
      c. Provide as single pole and electronic, multi-location control devices as indicated.
      d. Faceplate Finish/Color: Stainless Steel.
      f. Provide complete with separately installed power supply/control unit. Power supply/control unit shall be:
         1) A combination device providing 24VDC (100 mA) output from an input of either 120 or 277VAC input, to remotely connected devices.
         2) Provided with an integral switching duty relay, rated to interrupt not less than 16A @ either 120 or 277VAC.
3) Enclosed in a high impact, molded, thermoplastic housing, designed for field installation within or to a standard electrical outlet box.

g. Acceptable Manufacturers:
2) Or equivalent.

2.6 HOSPITAL GRADE RECEPTACLES

A. Standard Face - 20 amp, 125 volt, straight blade, NEMA 5-20R, duplex, grounding type, with integral grounding type brass strap.
   1. General Purpose:
   2. Power Verification (Lighted Face) Type: With integral electronics and illuminating device(s) that internally light the device face if the device is "energized":
   3. Tamper Resistant:

B. Decorator Face: 20 amp, 125 volt, straight blade, NEMA 5-20R, duplex, grounding type:
   1. Ground Fault Circuit Interrupting: With self-testing diagnostics and visual LED "Protection Assurance" indicator on face:
      a. Hubbell – GFRST83SNAP Series.
   2. Tamper Resistant/Ground Fault Circuit Interrupting: With visual LED "Protection Assurance" indicator on face:
      a. Hubbell – GFTWRST83SNAP Series.
   3. Combination AC/DC/USB Charging Type: Duplex NEMA 5-20R, 20A, 125 volts, hospital grade, tamper resistant, 3-wire grounding type AC receptacle, and two, 5 VDC USB 2.0 compatible with one Type A port and one Type C port factory assembled on a common, single gang wiring device strap. Shall provide USB shutoff circuitry to automatically stop charging when the connected device is fully charged.
      a. Hubbell - SNAP8300AC Series.

2.7 SPECIAL PURPOSE WIRING DEVICES

A. Emergency Power Off (EPO) Station:
   1. Heavy duty momentary contact red pushbutton with guard, flush stainless steel plate. Provide four (4) sets of contacts (minimum) allowing four (4) independent shunt trip panelboards per lab, and special backbox (as required). Nameplate per Division 26 Section "Electrical Identification" requirements.
   2. Allen Bradley, Cutler Hammer - Westinghouse, Square D, or Siemens Allis.

2.8 WIRING DEVICE ACCESSORIES

A. Indoor Coverplates:
1. General – Unless noted, shown, or otherwise indicated, provide to match the associated wiring device(s) configuration, style, and ganging.
   a. Provide single, multi-gang, and combination coverplates as required, specified, or otherwise indicated, to match the installed wiring device(s) configurations, and ganging.

2. Provide with metal screws for securing coverplates to device(s), with screw head color to match.
   a. Exception: Provide non-metallic, or non-ferrous coverplates and screws, over wiring devices installed in MRI suites.

3. Materials and Finishes:
   a. Stainless Steel – brushed finish, square corners, beveled edges and scratch resistant protective film.

4. For wiring devices installed in utilitarian spaces over surface mount outlet boxes, provide steel, wraparound, utility type outlet box covers.

5. Acceptable Manufacturers:
   a. By wiring device manufacturer.
   b. Mulberry Metal Products.

B. Outdoor/Wet Location Coverplates:
1. For switches installed outdoors, and switches installed indoors in wet locations, and switches indicated or noted with suffix "WP"; provide gasketed, weathertight cast, copper-free aluminum coverplates, with cast aluminum, lever arm style switch actuators, in corrosion resistant, epoxy paint finish, furnished complete with gasketing and stainless steel screws.
   a. Acceptable Manufacturers:

2. For receptacles installed outdoors, and receptacles installed indoors in wet locations, and receptacles indicated or noted with suffix "WP" provide gasketed, weathertight, cast aluminum, corrosion-resistant, wet location, outlet box covers, UL listed "Suitable for Wet Locations While in Use."
   a. Shall be rated NEMA 3R while in use, provided complete with closed-cell foam gasket, and shall be provided with padlocking provision.
   b. Shall be fabricated from die-cast aluminum alloy A360, with less than .004 copper content (copper free), provided with a factory applied aluminum lacquer finish.
   c. Provide size and configuration with intended use of receptacle.
   d. Acceptable Manufacturers:
      2) Or equivalent, submitted for approval.

2.9 TWIST-TO-LOCK RECEPTACLES
A. Single Receptacles, 125 volt, 20 amp: Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
1. Products: Subject to compliance with requirements, provide one of the following:
2.10 PENDANT CORD-CONNECTOR DEVICES

A. Description:
   1. Matching, locking-type plug and receptacle body connector.
   2. NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and FS W-C-596. Provide hospital grade receptacles where used in patient care areas.
   4. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.11 CORD AND PLUG SETS

A. Description:
   1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
   2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

2.12 TESTER

A. Provide two (2) receptacle circuit testers and two ground fault interrupter testers. Turn over to Owner upon completion.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
   1. Install wiring devices and accessories as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices to fulfill project requirements.
   2. Install hospital grade wiring devices throughout. Non-hospital grade devices may be installed in non-patient care areas only where approved in writing by Owner.
   3. Provide wall box dimmers and their related accessories to match, and be compatible with the provided luminaire light sources, ballast, drivers, transformers and other lighting components and devices.
   4. Provide simplex type receptacles within operating rooms, including on surgical booms wired to a dedicated circuit from source panelboard.
   5. Receptacles shown outdoors, and in indoor wet locations and as otherwise indicated with suffix WP, shall be GFCI, weather resistant type, provided with outdoor weatherproof covers and shall be installed per outdoor, wet location weatherproof construction methods.
6. Receptacles for supplying power to BAS control cabinets or equipment shall be on a dedicated circuit from a UPS branch panelboard. Cover plates for these dedicated receptacles shall be weatherproof-while-in-use large enough to accommodate a plug transformer and lockable in the closed position.

B. Coordination and Scheduling:
1. Coordinate with other Work, including painting, electrical boxes and wiring installations, as necessary to interface installation of wiring devices with other Work.
2. Install wiring devices in electrical boxes that are clean; free from building materials, dirt, and debris.
3. Install wiring devices after roughing wiring work is completed.
4. Install coverplates after painting work is completed. Provide blank coverplates at unused and/or barriered box locations unless otherwise directed by Owner.
5. Coordinate receptacles, shown within six feet of a sink or shown as exterior mounted, which shall be ground fault protected whether or not shown on Drawings.

C. Device Orientation:
1. In each instance where two or more devices are generally located in the same vicinity and at the same installation height, install these devices in multigang, barriered boxes under a single common coverplate.
2. Coordinate wiring device locations and heights with architectural elevations.
3. Unless noted otherwise, all wiring devices shall be installed in a vertical orientation.
4. Unless noted otherwise, lighting switches shall be installed such that the toggle handle "up" position turns the controlled lighting "ON".
5. Receptacle boxes provided for cabinetry and millwork shall be roughed 2 inches clear above counter backsplash or as otherwise shown on Drawings.
6. Receptacle boxes for water coolers shall be installed behind the cooler where recommended by manufacturer of the cooler.
7. Unless noted otherwise, duplex receptacles shall be installed in a vertical orientation with grounding pole up. Duplex receptacles installed 42 inches A.F.F. and above may be installed with grounding pole down.
8. Receptacles indicated or otherwise required to be installed horizontally, shall be installed with the neutral pole (grounded conductor) at the top uppermost position.

D. Device Conductor Terminations:
1. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 486A. Use properly scaled torque indicating hand tool.
2. Connect remote, maintained contact, emergency stop and test pushbutton devices ahead of all other motor control devices and to interrupt the motor control circuit in both the "Hand," and "Automatic" positions.

E. Coverplates:
1. Do not install midsize, oversized or extra-deep coverplates to conceal poor workmanship. Repair wall finishes and re-install outlet box if standard device coverplates do not fit flush or do not cover rough wall openings.
2. Install devices designated by suffix WP, with outdoor wet location coverplates, and associated outdoor, wet location installation methods.
3.2 IDENTIFICATION
   A. Comply with Division 26 Section "Electrical Identification."

3.3 PROTECTION
   A. Protect installed components from damage. Replace damaged items prior to final acceptance.

3.4 FIELD QUALITY CONTROL
   A. Perform tests and inspections and prepare test reports.
      1. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
      2. Test Instruments: Use instruments that comply with UL 1436.
   B. Tests for Convenience Receptacles:
      1. Line Voltage: Acceptable range is 105 to 132 V.
      2. Percent Voltage Drop Under a 15-amp Load: A value of 6 percent or higher is not acceptable. Test the last receptacle of the circuit.
      3. Ground Impedance: Values of up to 0.1 ohms are acceptable.
      4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
      5. Using the test plug, verify that the device and its outlet box are securely mounted.
      6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
      7. For Patient Care Space, test 100% of the receptacles/circuits, in non Patient Care Space test 50% of the receptacles/circuits, if all pass on the first test then the remaining are not required to be tested.
   C. In Patient Care Spaces all tests are to comply with the testing requirements of NFPA 99.

END OF SECTION 262726
SECTION 262800 - PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes circuit breakers, fusible disconnect devices and fuses rated 600 volts and less. Application, installation, and other related requirements for overcurrent protective device installations in other distribution equipment is specified in other Division 26 sections.

1.2 DEFINITIONS
A. Overcurrent Protective Device (OCPD): A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.

B. Ampere-Squared-Seconds: An expression of available thermal energy resulting from current flow. With regard to current-limiting fuses and circuit breakers, the ampere-squared-seconds during fault current interruption represents the energy allowed to flow before the fuse or breaker interrupts the fault current within its current limiting range.

1.3 LEGEND
A. AIC = Amperes interrupting capacity (K = 1000).
B. BIL = Basic impulse level (K = 1000).
C. Chg = Interchangeable.
D. GFI = Ground fault interrupting.
E. HID = Switching duty rated for HID or fluorescent fixtures.
F. Non = Non-interchangeable.
G. SWD = Switching duty rated at 20 ampere rating for fluorescent fixtures.
H. ZSI = Zone Selective Interlocking.

1.4 COMPATIBILITY
A. All protective devices in new assemblies shall be of the same manufacturer.
B. Protective devices added to existing assemblies shall have compatible interrupting ratings to the assembly and shall be of the original manufacturer. If not available, modify or extend the assembly to accept compatible protective devices of same manufacturer as supplied in new assemblies.
C. Series ratings of OCPDs are not acceptable.
D. A complete coordination study in accordance with Division 26 Section "Protective Device Coordination" shall be commissioned and paid for by Division 26. Series ratings of OCPD are not acceptable.
E. Provide compatible auxiliary solid-state functions as shown on Drawings for protective devices including:
   1. Communication Capability: Protective device communication module with functions and features compatible with power monitoring and control system.
   2. Zone Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
3. Arc Flash Protection System: Integral with electronic trip unit; for instantaneous trip function.

1.5 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.6 ACTION SUBMITTALS
A. Product Data: For fuses, fusible and non-fusible switches, circuit breakers, and OCPD accessories specified in this Section, including descriptive data and time-current curves for all protective devices and let-through current curves for those with current limiting characteristics. Include coordination charts and tables and related data.

1.7 INFORMATIONAL SUBMITTALS
A. Qualification Data:
   1. Testing Agent Qualifications.
B. Field Quality Control Test Reports:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
   4. Manufacturer's field service report.

1.8 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
   2. Time-current curves, including selectable ranges for each type of circuit breaker.
   3. Include final fuse type and ratings as well as served equipment list for all installations.
   4. Include "as-designed" and "as-left" OCPD adjustable settings list for all installations.
   5. Include key interlock sequence of operation per assembly.
B. Record Documents.

1.9 QUALITY ASSURANCE
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
B. Comply with NFPA 70.
C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed protective devices, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
D. Series rating of OCPDs is not acceptable.

PROTECTIVE DEVICES
E. Field Testing: Refer to Division 26 Section “Electrical Inspections and Testing” for field inspections and testing requirements related to this Section including:

2. General Electrical Field Quality Control.


1.10 PROJECT CONDITIONS
A. Environment Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg. F (minus 30 deg. C) and not exceeding 104 deg. F (40 deg. C).

1.11 COORDINATION
A. Coordinate layout and installation of protective devices and their associated enclosures and components with other construction, including conduit, piping, equipment and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.12 REFERENCES AND STANDARDS
A. Enclosures:

1. NEMA 250-85 - Enclosures for Electrical Equipment (1,000 Volts, maximum).

B. Molded Case and Insulated Case Circuit Breakers:

1. UL 489 - Molded Case Circuit Breakers and Circuit Breaker Enclosures.
2. NEMA AB1 - Molded Case Circuit Breakers.

C. Cartridge Type Fuses:

1. NEMA FU1 - Low Voltage Cartridge Fuses.
2. UL 198C - High-Interrupting Capacity Fuses, Circuit Limiting Type.
3. UL 198E - Class R Fuses.

D. Disconnect Switches:

1. UL 98-87 - Enclosed and Dead Front Switches.
2. NEMA K-85 - Enclosed Switches.
3. UL 977-84 - Fused Power Circuit Devices.

E. Low Voltage Drawout Power Circuit Breakers:

1. UL-1066 - Low Voltage AC and DC Power Circuit Breakers.

PART 2 - PRODUCTS

2.1 THERMAL-MAGNETIC MOLDED CASE CIRCUIT BREAKERS

A. Manufacturers:
1. Basis of Design: Square D; Schneider Electric.

2. Acceptable Equivalents/Manufacturers as approved by Owner, submit as substitution request per Division 1.

B. Construction:

1. Tripping Mechanisms: Inverse time delay thermal element for long-time overload tripping and an instantaneous magnetic trip element set to operate at 7 to 10 times the long-time trip setting for high fault current tripping in each phase. Common trip for multiple breakers without the use of handle ties. Trip-free over center quick-make, quick-break switching mechanism shall provide distinctive handle positions to self-indicate automatic tripping.

2. Enclosure: Bakelite, epoxy, glass-fibered reinforced polyester or similar material required to obtain interrupting rating.

3. Mounting: Bolt-in. Rating labels shall be visible when breaker is installed.

4. Terminal Lugs: Suitable for quantity of wire or bus to be attached; mechanical type for copper wire, compression type for aluminum wire, and bolted for bus connections.

C. Ratings:

1. Trip: As scheduled.

2. Frame: Provide as scheduled as minimum requirement.

3. AIC: Provide as scheduled as minimum requirement.

D. Special Features: Interchangeable trip settings, shunt trip, undervoltage trip, alarm switch, auxiliary switch, motor operator, etc., as shown on Drawings.

1. Molded case switch shall have manual only tripping mechanism.

2.2 SOLID-STATE MOLDED CASE CIRCUIT BREAKERS

A. Manufacturers:

1. Basis of Design: Square D; Schneider Electric.

2. Acceptable Equivalents/Manufacturers as approved by Owner, submit as substitution request per Division 1.

B. Construction:

1. Standard Tripping Mechanism: Solid-state tripping elements with associated current monitor and flux transfer shunt trip in two or three pole applications. Sensors shall be provided for each pole. Long-time trip settings shall be adjustable using rating plug and dials covering a minimum range of 50 – 100 percent of the specified rating. Hand held battery operated programmers are acceptable; however, provide a minimum of (2) programmers, a wall mountable galvanized steel storage box and provide a minimum of (2) 4 hour additional training sessions for the Owner. The magnetic trip unit shall have adjustable short-time and instantaneous trip characteristics. Trip unit shall be common for all poles, trip-free, over center quick-make quick-break switching and consist of a manual trip button and trip indicators. The trip device shall be insensitive to temperature changes between minus 20 degrees C and plug 55 degrees C. The long-time delay, short-time pickup, short-time delay and instantaneous pickup shall be fully adjustable using dials, with the following minimum characteristics, based on the coordination study, settings and adjustments may override specification generalities:

   a. Long-time pickup (0.5 – 1) x plug rating.

   b. Long-Time Delay:

      1) 600 amps and below (2-14 seconds).

      2) Above 600 amps (2-24 seconds).
2.3 LOW-VOLTAGE DRAWOUT POWER CIRCUIT BREAKERS

A. Manufacturers:
   1. Basis of Design: Square D; Schneider Electric.
   2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

B. Ratings: As indicated for continuous current, interrupting, and short-time current ratings for each circuit breaker. Voltage and frequency ratings same as switchgear. Circuit-breaker frame sizes shall be based on NEMA defined "rated continuous current."

C. Operating Mechanism: Mechanically and electrically trip-free, stored energy operating mechanism.
   1. Closing speed of the moving contacts shall be independent of both control and operator.
   2. Provide for manual charging of the mechanism and for slow closing of the contacts for inspection and adjustment.
   3. Stored Energy Mechanism: Manually or electrically charged as indicated.

C. Ratings:
   1. Trip: As scheduled.
   2. Frame: Provide as scheduled as minimum requirement.
   3. Sensor-Clip shall match frame size.
   4. AIC: Provide as scheduled as minimum requirement.

D. Special Features: Interchangeable trip settings, shunt trip, undervoltage trip, bell alarm, auxiliary switch, motor operator, etc., as shown on Drawings.
   1. Molded case switch shall have manual only tripping mechanism.
4. Operation Counter: Include except as otherwise indicated.
5. Digital power meter.

D. Circuit-Breaker Trip Devices: Solid-state overcurrent trip device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
1. Functions: Long-time delay, short-time delay, and instantaneous trip functions, independent of each other in both action and adjustment.
2. Temperature compensation to assure accuracy and calibration stability from minus 5 deg C to plus 40 deg C.
3. Field-adjustable time current characteristics.
4. Current adjustability effected by changing dial settings and rating plugs on trip units or sensors on circuit breakers or a combination of these methods.
5. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
6. Five pickup points, minimum, for long-time-trip and short-time-trip functions. Short-time-trip function equipped for switchable I^2t operation.
7. Five pickup points, minimum, for instantaneous trip functions.
8. Ground fault protection with at least three short-time-delay settings and three trip-time-delay bands. Adjustable current pickup. Arranged to provide the following types of protection as indicated.
   a. Protection for 3-wire circuit or system.
   b. Protection for 4-wire circuit or system.
   c. Protection for 4-wire double-ended substation.
9. Trip Indication: Labeled battery-powered lights or mechanical targets on trip device to indicate type of fault causing breaker trip.

E. Auxiliary Contacts for Remote Indication and monitoring: For remote indication of breaker position and meter data, provide a spare auxiliary switch in addition to other auxiliary switches required for the normal breaker operation. The spare auxiliary switch shall consist of 2 Type "a" and 2 Type "b" stages (contacts) wired through secondary disconnecting devices to a terminal block in the stationary housing.

F. Drawout Features: Circuit breaker mounting assembly equipped with a racking mechanism to properly position the power circuit breaker and hold it rigidly in connected, test, and fully disconnected positions. Include the following features:
1. Interlock arrangement preventing movement of the circuit breaker to or from the connected position when it is in the closed position and closure of the circuit breaker unless it is in the connected, test, or disconnected position.
2. Construction permitting racking an open circuit breaker to or from the connected, test, and disconnected positions with the associated compartment door closed (unless live parts are covered by a full dead-front shield), and manual withdrawal to a position for removal from the structure with the door open.
3. Primary disconnecting devices disengaged and secondary disconnecting devices engaged when breaker is in test position.
4. Primary and secondary devices disengaged when circuit breaker is in the disconnected position.
5. Ground contact engaged when the circuit breaker element is in the connected and test positions.
6. Remote Racking and Control device which is capable of inserting, removal, open and closing of drawout breakers while the operator is outside the flash protection boundary.

G. Circuit Breaker Features: Include the following:
1. Arc Chutes: Readily removable from the associated circuit breaker when it is in the disconnected position, and arranged to permit inspection of the contacts without removing the breaker from the switchgear.

2. Padlocking Provisions: For installing at least three padlocks on each breaker to secure its enclosure and prevent movement of the drawout mechanism.

3. Operating Handle: One for each manually operated breaker.

4. Electric Close Button: One for each electrically operated breaker.

H. Interlocking of breakers shall use a mechanical tripping lever or equivalent design in addition to electrical interlocks.

I. Key Interlocks: Arrange interlocking so keys are held captive at devices indicated. Where provision for future key interlocking is indicated, provide all necessary mountings and hardware as required for the future installation of key interlock devices.

J. Instantaneous Undervoltage Trip Device: For circuit breakers indicated.

K. Adjustable Time Delay Undervoltage Trip Devices: For circuit breakers indicated.

L. Shunt Trip Devices: Where indicated, arrange to trip breaker from an external source of power through a control switch or protective relay contacts and the secondary disconnecting devices. If a 120V source is used, it shall be supplied from the control power transformer.

M. Ratings:
   1. Trip: As scheduled.
   2. Frame: Provide as scheduled as minimum requirement.
   3. AIC: Provide as scheduled as minimum requirement.

2.4 SEPARATELY ENCLOSED CIRCUIT BREAKERS

A. Enclosure:
   1. Flush or surface as shown on Drawings.
   2. Type shall suit area per NEMA requirements.
      a. Indoor – NEMA 1
      b. Wet Locations – NEMA 3R
      c. Parking decks & areas subject to salt spray – 316 stainless steel enclosure
   3. Ground wire lug of suitable size shall be bolted to the enclosure. Neutral bar on four wire systems shall be ungrounded.
   4. Nameplate centered on front shall identify load served.

B. Breaker characteristics shall be as previously specified.

2.5 CARTRIDGE TYPE FUSES

A. Make: Copper Industries, Inc. - Bussmann, Chase-Shawmut, Economy, Littlefuse.

B. Fuses, General:
   1. General: Provide fuses of types, classes, and current ratings as indicated. Voltage ratings shall be consistent with the circuits on which used.
   2. Fuses for Direct Current Circuits: Marked for such use by the manufacturer on the fuse label.

C. Application of Fuses:
   1. General: Apply fuses as indicated and as follows:
2. New General Purpose Fusible Switches: Apply the following class types:
   a. 0 - 600 Amperes: Class RK1, dual element time delay; LPN-RK, LPS-RK.
   b. 601 - 1,200 Amperes, Motor or Transformer Circuit: Class L, time delay; Lo-Peak KRPC.
   c. 601 - 1,200 Amperes, Noninductive Circuit: Class L, fast acting.
4. Service Protectors: Class L, time delay.
5. Fusible Switch Panelboards: Class RK1, time delay.
6. Motor Fused Disconnect Switches and Combination Controllers: Class RK1, dual element time delay; LPN-RK, LPS-RK.
7. Switches in Switchboards: Apply the following classes and types:
   a. 60 - 600 Amperes: Class RK1, dual element time delay; LPN-RK, LPS-RK.
   b. 601 Amperes and Above: Class L, time delay; Lo-Peak KRPC.
8. Existing General-Purpose Switches: Apply the following classes and types:
   a. 30 - 600 Amperes: Class RK1, dual element time delay; LPN-RK, LPS-RK.
   b. 601 - 1,200 Amperes: Class L, time delay; Lo-Peak KRPC.

2.6 DISCONNECT SWITCHES

A. General:
   1. Disconnect switches for 120 VAC equipment shall be manual fractional horsepower motor controllers, as specified in Division 26 Section "Motor Controllers," with engraved coverplate identifying load served.
   2. Other disconnect switching shall be as specified below.

B. Manufacturers:
   1. Basis of Design: Square D; Schneider Electric.
   2. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

C. Construction:
   1. Heavy duty type, fused and/or non-fusible as shown on Drawings.
   2. Interior Construction: Switch blades fully visible in the off position when the enclosure door is open. Fuse holders for specified fuse, rejection type.
   3. Switch Mechanism: Quick make, quick break with positive interlock to prevent opening of enclosure door when operating handle is in the on position and to prevent closing of the switch mechanism with the door open. Operating handle shall be an integral part of enclosure base, have provisions for three padlocks in the off position, and the means to indicate whether the switch is on or off by its position. Vertical operating handles shall be up in the on position.
   4. Terminal Lugs: Suitable for quantity of wire to be attached, front removable with terminal shields; mechanical type for copper wire, compression type for aluminum wire.

D. Ratings:
   1. Amperes: 30 - 1200.
   2. Voltage: 240 or 600.
   3. Poles: 2, 3, or 6.
   4. AIC: Match fuse or upstream protective device.
   5. Horsepower Rated: 30 - 600 amps.
E. Enclosure:
   1. Surface mounted type.
   2. Type shall suit area per NEMA requirements.
      a. Indoor – NEMA 1
      b. Wet Locations - NEMA 3R
      c. Parking decks & areas subject to salt spray – 316L stainless steel enclosure
   3. Ground wire lug of suitable size shall be bolted to the enclosure. Neutral bar on four wire systems shall be ungrounded.
   4. Nameplates on front shall identify load service as well as proper fuse application warning.

F. Special Features: Service entrance rated, control circuit interlock, etc., as shown on Drawings.
   1. Label each safety switch per Division 26 Section "Electrical Identification," with the following legend in capital lettering at least 3/8 inch high: "DANGER, DO NOT START OR STOP MOTOR WITH THIS SWITCH. USE FOR ISOLATION ONLY."
   2. Where indicated (by subscript "AUX") provide not less than one set of Form C (1 N.O & 1 N.C) auxiliary contacts, mechanically interlocked to the switch operating handle, such that the N.C. contact opens prior to the switch blades closing, of the N.O. contact closes prior to the switch blades opening.
      a. Contacts shall be rated not less than 15A continuous, @ 240 V AC.

2.7 FUSEHOLDERS
A. Provide fuse holders to accommodate the fuses specified. Coordinate installation with assembly manufacturers as applicable.
   1. Terminal Lugs: Suitable for quantity of wire or bus to be attached; mechanical type for copper wire, compression type for aluminum wire, and bolted for bus connection.

2.8 KEY INTERLOCKS
A. General:
   1. Mechanical keyed protective device shall enhance electrical safety to permit sequencing of switching type protective devices with other keyed switching devices or enclosures. Specific functionality and sequencing shall be per assembly specifications and as shown on Drawings. Note that multiple keys may be required for some single safe operation sequence applications.
   2. All keys shall remain captured in the frame except when the switching type protective device has been locked in the OPEN position when a brass mechanical slip bolt has been extended to prevent closure.
   3. Key type shall be assembly specific and shall not be compatible with associated assembly door interlock and padlock devices. Keys shall be engraved with identifying number. One spare set of keys per assembly shall be turned to Owner and shall be properly mounted in a lockable NEMA 1 cabinet per Division 26 Section "Boxes and Cabinets". Identify KEY INTERLOCK SPARES per Division 26 Section "Electrical Identification."
   4. Padlocking in lieu of slip bolt type key interlocks is not acceptable.
   5. The lock assemblies shall be securely mounted to enhance safety.

B. Make: As recommended by assembly manufacturer.
2.9 ZONE SELECTIVE INTERLOCKING (ZSI) SYSTEM

A. General:
   1. Assembly integrated microprocessor based system providing communication between main and feeder breakers to insure fast feeder breaker clearing of downstream instantaneous region disturbances (short circuit or ground fault conditions) without nuisance tripping of the main breaker.

B. Function:
   1. Feeder breaker closest to the fault will ignore its preset short time and grand fault delays and open to clear the fault with no intentional delay. Other branch and main protective devices will be restrained – remain closed to maintain service to unaffected loads via the communication link.

C. Application:
   1. Required for enhanced coordination or reduced arc flash category as indicated or as defined by the coordination study results of Division 26 Section "Protective Device Coordination".
   2. Required as a component of indicated Arc Flash Protection Systems

2.10 ACCESSORIES

A. Provide breaker accessories for general operation and maintenance of specified breakers. Include items listed below and items recommended by manufacturer:
   1. Test kit for each type of drawout, solid state, and power air breaker.
   2. Handle extensions for low voltage devices 1200 amperes and larger.
   3. Drawout sticks.
   4. Special adjustment tools.

B. Provide fuse accessories for general operation and maintenance of specified fuses. Include items listed below and items recommended by manufacturer.
   1. Fuse pullers.
   2. Fuse pull rings.
   3. Handling poles with extensions.
   4. Pole grapples, prongs, clamps, etc.

C. Unless declined otherwise by the Owner, provide, in a surface wall mounted cabinet, per Division 26 Section "Boxes and Cabinets", three (3) spare fuses of each size and type utilized on the project neatly arranged in clips or holders. Provide SPARE FUSES cabinet nameplate centered on front.

D. Provide quantities of circuit protective accessories in locations necessary for effective general operation.

E. Provide breaker handle clips in on position at all breakers serving fire alarm equipment. Include equipment identification label "Fire Alarm System" at breaker per Division 26 Section "Electrical Identification."

F. Fire pump feeder breakers and disconnects shall have provision to padlock operating handle in on position.
3.1 INSTALLATION

A. Install circuit protective devices in assemblies at or above the minimum interrupting rating and frame size shown on Drawings. Circuit breaker frame size shall be the largest ampere rating if not specified in the rating schedules.

B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration Controls."

C. Add new circuit protectives to existing assemblies when shown on Drawings. Rearrange existing circuit protective and provide bus extensions, hardware, enclosure modifications, etc., to accomplish the installations. Modify assemblies directories or add nameplates to match existing.

D. Install separately enclosed circuit breakers and disconnect switches at six feet above floor unless otherwise noted. Support independent of stud partitions.

E. Install fused disconnect switches as shown on Drawings and Schedules, complete with fuses recommended by the manufacturer of the equipment served. Ensure proper AIC ratings for protection of the switch and equipment. Submit final fuse ratings as part of O&M Manual submission. Series ratings of OCPD are not acceptable.

F. Install distribution equipment circuit protective devices at factory.

G. Leave all spare devices in the off position.

H. Coordinate factory or field installation of key interlocks and associated sequence of operation nameplate per assembly per Division 26 Section "Electrical Identification."

I. Install spare fuse cabinet at location shown on Drawings.

J. Install key interlock spares cabinet at Owner designated location.

3.2 IDENTIFICATION

A. Identify components in accordance with Division 26 Section "Electrical Identification."

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between OCPDs and control/indication devices as specified in Division 26 Section "Low Voltage Electrical Power Conductors and Cables" for hard wired connections.

3.4 CONNECTIONS

A. Check connectors, terminals, bus joints, and mountings for tightness. Tighten field-connected connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and UL 486B.

3.5 GROUNDING

A. Provide equipment grounding connections for individually mounted OCPD units as indicated, as required by NEC, and per Division 26 Section "Grounding and Bonding." Tighten connectors to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounding.
3.6 FIELD QUALITY CONTROL

A. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.

B. Schedule visual and mechanical inspections and electrical tests with at least one week's advance notification.

C. Pretesting: Upon completing installation of the system, perform the following preparations for independent tests:
   1. Make insulation resistance tests of OCPD buses, components, and connecting supply, feeder, and control circuits.
   2. Make continuity tests of circuits.
   3. Provide set of Contract Documents to test personnel. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents.
   4. Provide manufacturer's instructions for installation and testing of OCPDs to test personnel.

D. Test and Inspections:
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS "Switches, Air, Low Voltage", Circuit Breakers, Air Insulated Case/Molded Case", "Circuit Breakers Air, Low Voltage Power", "Ground-Fault Protection System", "System Functional Tests" and Thermographic Survey requirements including option requirements and the following additional requirements:
      a. Limit tests to:
         1) All non branch circuit breakers.
      b. Follow-up 12 month thermographic survey shall not be required.
      c. Check key and other interlock and safety devices for operation and sequence. Make closing attempts on locked-open and opening attempts on locked-closed devices including moveable barriers and shutters.
      d. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. Training: Arrange and pay for the services of factory-authorized service representatives to demonstrate OCPDs and train Owner's maintenance personnel.

B. Conduct a minimum of one half day of training in operation and maintenance as specified under "Instructions to Owner Employees" in the "Project Closeout" Section of these Specifications. Include both classroom training and hands-on equipment operation and maintenance procedures.

C. Schedule training with at least seven (7) days' advance notification.

END OF SECTION 262800
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes motor controllers rated 600 V and less that are not supplied with equipment furnished by other Divisions.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 26 "Basic Division 26 Requirements."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of enclosed controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings:

1. Layout Drawings: Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
   a. Each installed unit's type and details.
   b. Nameplate legends.
   c. Short-circuit current rating of integrated unit.
   d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.

2. Wiring Diagrams: Power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer and testing agency.

B. Field quality control test reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for enclosed controllers and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

B. Record Documents:

1. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed controllers, minimum clearances between enclosed controllers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

E. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
   2. General Electrical Field Quality Control.


1.7 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.8 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Construction Manager and Owner no fewer than fourteen (14) days in advance of proposed interruption of electrical service.
   2. Indicate method of providing temporary utilities.
   3. Do not proceed with interruption of electrical service without Construction Manager's or Owner's written permission.

1.9 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 26 Section Hangers and Supports”.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

D. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Basis of Design: Square D; Schneider Electric.
   2. Acceptable Equivalents/Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.2 MOTOR CONTROLLERS, GENERAL

A. Controller shall be manual type for motors 1/3 HP and smaller and magnetic type for motors 1/2 HP and larger.

B. Coordinate the features of each motor controller with the ratings and characteristics of the supply circuit, the motor, the required control sequence, the duty cycle of the motor, drive, and load, and the pilot device, and control circuit affecting controller functions. Provide controllers that are horsepower rated to suit the motor controlled.

C. Contacts shall open each ungrounded connection to the motor.

D. Controller contacts shall be twin-break, silver-to-silver, renewable contacts with one set of contacts for each phase.

E. Overload Relays: Solid state ambient-compensated type with inverse-time-current characteristic. Provide with sensors in each phase matched to nameplate full-load current of the specific motor to which connected with appropriate adjustment for duty cycle.

F. Enclosures: For individually mounted motor controllers and control devices, comply with NEMA Standard 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)." Provide enclosures suitable for the environmental conditions at the controller location. Provide NEMA Type 1 enclosures except as otherwise indicated.

G. The coverplate shall have a lock-off tab for a padlock.

2.3 MANUAL FRACTIONAL HORSEPOWER MOTOR CONTROLLERS

A. Description: Quick-make, quick-break toggle action.

B. Single-phase motor control switches (thermal switches) for fractional horsepower motors. Single pole for 120 volt, two pole for 208 volt operation. Mount flush in finished areas and surface otherwise.

C. Trip-free, toggle operated with on-off-reset position clearly indicated with neon pilot light for run indication.

D. Thermal overload shall be ambient compensated, plug-in type element with heater rating clearly indicated. Provide one overload for single pole switch and two overloads for two pole switch.

E. Where the motor is interlocked and controlled by another device, the motor controller shall be marked "Hand-Off-Auto."
2.4 COMBINATION MAGNETIC MOTOR CONTROLLERS

A. Description: Provide full-voltage, nonreversing, across-the-line, magnetic controller, except where another type is indicated.

B. Control Circuit: 120 V. Provide control power transformer integral with controller where no other supply of 120 V control power to controller is indicated. Provide control power transformer with adequate capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

C. Combination Controller: Switch type; fused or unfused as indicated; quick-make, quick-break switch; factory assembled with controller, and arranged to disconnect it. For fused switches, provide rejection-type fuse clips and fuses rated as indicated. Switches and fuses are specified in Division 26 Section "Protective Devices." Interlock switch with unit cover or door.

D. Enhanced-Protection Overload Relay: Provide solid state overload relays with NEMA Class 10 tripping characteristics. Select to protect motor against voltage unbalance and single phasing.

E. Enclosure door shall be interlocked with the operating handle to prevent opening of doors with handle in the on position.

F. Shall be provided with the following pilot lights:
   1. Green light to indicate motor running.
   2. Red light to indicate motor off.

G. Provide Type 2 coordination (no damage protection) for motor starter per UL 508E requirements.

2.5 COMBINATION 2-SPEED MAGNETIC MOTOR CONTROLLERS

A. General: Match controller to motor type, application, and to number of speeds. Conform to Article "Magnetic Motor Controllers" above. Provide auxiliary devices as indicated herein and on Drawings. Provide all required relays factory installed in controller enclosure.

B. Combination starters shall be across-the-line full voltage, non-reversing type with undervoltage release for 2 speed motors. Be factory assembled and include magnetic type controllers and motor circuit protector.

C. The controller shall serve the purpose of starting a 2-speed motor at the pre-selected speed and to provide complete overload, overcurrent, and undervoltage protection at each speed.

D. The 2-speed controller shall basically be an assembly of two magnetic across-the-line controllers, one for each motor speed, mechanically and electrically interlocked and wired for automatic control through a cover mounted control switch. Include single phase protection and voltage unbalance trip relays.

E. Controller shall be provided with the following pilot lights:
   1. Green light to indicate motor high speed.
   2. Amber light to indicate motor low speed.
   3. Red light to indicate motor off.

F. Decelerating Relay: Provide selection of lower than current operating speed by pushbutton or pilot device as indicated with deceleration automatically timed through any intervening speeds.
2.6 AUXILIARY CONTROL DEVICES

A. General: Factory installed in controller enclosure except as otherwise indicated. Where separately mounted, provide NEMA 1 enclosure except as otherwise indicated.

1. Control circuit shall be a maximum of 120 volts with individual control power transformer having Class CC dual primary and single secondary fused protection. Provide terminal lugs for connection to wiring from external remote located controls. Where indicating lights, solenoid valves and additional control components are energized from the control transformer, the control power transformer will be increased in size to handle its normal load plus the other indicated loads.

B. Control devices such as pushbuttons and selector switches shall be heavy-duty, oil-tight, and be key operated or lockable where shown on Drawings.

C. Control selector switches shall be as shown on Drawings and shall be one of the following:

1. Start-Stop.
2. Off-Auto (O-A).

D. Provide each H-O-A switch with momentary stop and start push buttons located in the "H" leg to prevent accidental starting when the switch is turned to the "H" position.

E. Control devices shall be mounted in starter cover and be labeled with the motor or assembly which they service.

F. Control functions shall assure proper fire alarm system overrides. If such overrides are through Division 23 or 25 hardware/software, coordinate per Division 28 Section "Fire Alarm Systems" requirements.

G. Pilot lights shall be transformer type, heavy-duty, oil tight.

H. Provide 1 "NO" and 1 "NC" isolated auxiliary contacts in addition to the normal hold-in contact and auxiliary contacts required for interlocks and pilot lights.


J. Provide Ground Fault Relays: With sensing circuit and adjustable trip settings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers for compliance with requirements, installation tolerances, and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Coordinate motor control equipment with the motor being supplied. Refer to motor controller schedules on Drawings. Note that scheduled motor circuit protectors are based on continuous duty ratings.

B. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.
C. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

A. Location: Locate controllers as indicated and within sight of motors controlled approximately where shown on Drawings.

B. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports."

1. Individually mounted magnetic and manual controllers mounted in finished areas shall be flush. Flush coverplates shall be stain finish, stainless steel for manual starters or painted finish for magnetic controllers. Manufacturer’s nameplates or holes resulting there from will not be permitted.

C. Maintain minimum clearances and workspace at equipment according to manufacturer’s written instructions and NFPA 70.

D. Enclosed Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Protective Devices."

E. For magnetic controller/controllers, combination fused or motor circuit protector type shall be used. If fuses are indicated, the motor circuit protector shall be equipped with current limiters.

F. Where interlocking or sequence starting of motors is shown on Drawings, it shall be done such that when the circuit feeding a starter is open, no part of the controller/controllers shall be energized. Furnish any relates, auxiliary contacts or disconnect switches necessary to implement the indicated sequences and interlocks.

G. Provide permanent wiring diagrams as approved by the Engineer showing all internal starter controller within each motor controller/controllers compartment. Glued-on blueline prints are not acceptable. Also provide interlock wiring diagrams between controller/controllers.

H. Overloads shall be of NEMA size required to match the specified motor nameplate (and power factor capacitor data).

I. Provide wiring from the controller to the motor. For 2-speed, 3-phase controller/controllers, provide three or six wires as required by the controller/controllers type.

3.4 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Division 26 Section "Hangers and Supports," and concrete materials and installation requirements are specified in Division 03.

3.5 IDENTIFICATION

A. Identify enclosed controller, components, and control wiring according to Division 26 Section "Electrical Identification."

3.6 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.
3.7 CONNECTIONS
   A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate
genral arrangement of conduit, fittings, and specialties.
   B. Ground equipment according to Division 26 Section "Grounding and Bonding."

3.8 FIELD QUALITY CONTROL
   A. Prepare for acceptance tests as follows:
      1. Test insulation resistance for each enclosed controller element, bus, component,
         connecting supply, feeder, and control circuit.
      2. Test continuity of each circuit.
   B. Tests and Inspections:
      1. Perform inspections and test procedures as required by Division 26 Section "Electrical
         Inspections and Testing", ANSI/NETA ATS "Motor Control, Motor Starters, Low-Voltage",
         "System Functional Tests", and "Thermographic Survey" requirements and the following
         additional requirements.
         a. Follow-up 12 month thermographic survey shall not be required.
         b. Correct malfunctioning units on-site, where possible, and retest to demonstrate
            compliance; otherwise, replace with new units and retest.
         c. Prepare test and inspection reports.

3.9 ADJUSTING
   A. Set field adjustable switches and circuit-breaker trip ranges.

END OF SECTION 262913
PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes slow-transfer battery inverters with the following features:
   1. Internal maintenance bypass/isolation switch.
   2. Emergency-only circuits.

1.2 DEFINITIONS
A. LCD: Liquid-crystal display.
B. LED: Light-emitting diode.
C. THD: Total harmonic distortion.
D. UPS: Uninterruptible power supply.

1.3 SUBMITTALS
A. General: submit the following in accordance with Division 26 Section "Common Work Results for Electrical."

1.4 ACTION SUBMITTALS
A. Product Data: For the following:
   1. Electrical ratings, including the following:
      a. Capacity to provide power during failure of normal ac.
      b. Inverter voltage regulation and THD of output current.
      c. Rectifier data.
      d. Transfer time of transfer switch.
      e. Data for specified optional features.
   2. Transfer switch.
   3. Inverter.
   4. Battery charger.
   5. Batteries.
   7. Battery-cycle warranty monitor.
B. Shop Drawings:
   1. Layout Drawings: Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
   2. Wiring Diagrams: Detail internal and interconnecting wiring; and power, signal, and control wiring.
   3. Elevation and details of control and indication displays.
   4. Output distribution section.
1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. Source quality control test reports.
   2. Warranty: Special warranty specified in this Section.
   3. For testing agency.

B. Field quality control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For battery inverter equipment to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
   2. General Electrical Field Quality Control.


1.8 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
   1. Ambient Temperature: Not exceeding 104 deg F (40 deg C).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet (2000 m).

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment in fully enclosed vehicles.

B. Store equipment in spaces having environments controlled within manufacturers’ written instructions for ambient temperature and humidity conditions for non-operating equipment.

1.10 WARRANTY

A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace batteries that fail in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.

   1. Warranty Period: Include the following warranty periods, from date of Substantial Completion:
      a. Standard, Valve-Regulated, Recombinant, Lead-Calcium Batteries:
PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Isolite Corporation – E3 Series.

2.2 REGULATORY REQUIREMENTS
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   B. Battery Inverter System: UL 924 listed.

2.3 INVERTER PERFORMANCE REQUIREMENTS
   A. Slow-Transfer Central Battery Inverters: Automatically sense loss of normal ac supply and use an electromechanical switch to transfer loads. Transfer in one second or less from normal supply to battery-inverter supply.
      1. Description: A factory-fabricated unit that uses an integral battery source, an inverter, and automatic control and switching to provide both normal and emergency or standby electrical supply for alternating current branch circuit loads.
      2. Operation: Unit supplies power to output circuits from a single, external, normal supply source. Unit automatically transfers load from normal source to internal battery/inverter source. Retransfer to normal is automatic when normal power is restored.
   B. Maximum Acoustical Noise: 40 dB, "A" weighting, emanating from any UPS component under any condition of normal operation, measured 39 inches (990 mm) from nearest surface of component enclosure.

2.4 INVERTERS
   A. Description: Solid-state type, with the following operational features:
      1. Automatically regulate output voltage to within plus or minus 5 percent.
      2. Automatically regulate output frequency to within plus or minus 1 Hz, from no load to full load at unit power factor over the operating range of battery voltage.
      3. Output Voltage Waveform of Unit: Sine wave with maximum 10 percent THD throughout battery operating-voltage range, from no load to full load.
         a. THD may not exceed 5 percent when serving a resistive load of 100 percent of unit rating.
2.5 BATTERY CHARGER  
A. Description: Solid-state, automatically maintaining batteries in fully charged condition when normal power is available. With LED indicators for "float" and "high-charge" modes.

2.6 BATTERIES  
A. Description: Standard, valve-regulated, recombinant, lead-calcium batteries.  
1. Capable of sustaining full-capacity output of inverter unit for minimum of 90 minutes.

2.7 ENCLOSURES  
A. NEMA 250, Type 1 steel cabinets with access to components through hinged doors with flush tumbler lock and latch.  

2.8 CONTROL AND INDICATION  
A. Description: Group displays, indications, and basic system controls on common control panel on front of central battery inverter enclosure.  
B. Minimum displays, indicating devices, and controls shall include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms shall include an audible signal and a visual display.  
C. Indications: Plain-language messages on a digital LCD.  
1. Quantitative Indications:  
   a. Input voltage, each phase, line to line.  
   b. Input current, each phase, line to line.  
   c. System output voltage, each phase, line to line.  
   d. System output current, each phase.  
   e. System output frequency.  
   f. DC bus voltage.  
   g. Battery current and direction (charge/discharge).  
   h. Elapsed time-discharging battery.  
2. Basic Status Condition Indications:  
   a. Normal operation.  
   b. Load-on bypass.  
   c. Load-on battery.  
   d. Inverter off.  
   e. Alarm condition exists.  
3. Alarm Indications:  
   a. Battery system alarm.  
   b. Control power failure.  
   c. Fan failure.  
   d. Overload.  
   e. Battery-charging control faulty.  
   f. Input overvoltage or undervoltage.  
   g. Approaching end of battery operation.
h. Battery undervoltage shutdown.
i. Inverter fuse blown.
j. Inverter transformer overtemperature.
k. Inverter overtemperature.
l. Static bypass transfer switch overtemperature.
m. Inverter power supply fault.
n. Inverter output overvoltage or undervoltage.
o. System overload shutdown.
p. Inverter output contactor open.
q. Inverter current limit.

4. Controls:
a. Inverter on-off.
b. Start.
c. Battery test.
d. Alarm silence/reset.
e. Output-voltage adjustment.

D. Dry-form "C" contacts shall be available for remote indication of the following conditions:
1. Inverter on battery.
2. Inverter on-line.
3. Inverter load-on bypass.
4. Inverter in alarm condition.
5. Inverter off.

E. Include the following minimum array:
1. Ready, normal-power on light.
2. Charge light.
3. Inverter supply load light.
4. Battery voltmeter.
5. AC output voltmeter with minimum accuracy of 2 percent of full scale.
7. Test switch to simulate ac failure.

F. Enclosure: Steel, with hinged lockable doors, suitable for wall mounting. Manufacturer’s standard corrosion-resistant finish.

2.9 COMMUNICATIONS

A. Remote Monitoring:
1. The Inverter shall be able to be monitored remotely via communications devices. Manufacturer shall provide communications devices capable of communication via various industry-standard protocols.
   a. Communication Protocols:
      1) BACNet.

2. The communication capability should be able to integrate into any industry standard Building Management System (BMS) and/or Network Management System (NMS). The UPS must also be able to be monitored via any standard Internet browser (i.e. Internet Explorer Chrome, or Firefox).
B. Remote Monitoring Parameters: Inverter shall communicate the following values:

1. Program the following alarms:
   a. Battery Low Shutdown
   b. Battery Low (low battery threshold at 50%).
   c. Output Load on Maintenance Bypass.
   d. Battery Discharging.
   e. System Output Off.
   f. General Alarm (all other system alarms).

2. Program the following Status:
   a. Battery Charging.
   b. System Status.

2.10 SOURCE QUALITY CONTROL

A. Factory test complete inverter system, including battery, before shipment. Include the following:

1. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.
2. Full-load test.
4. Overload test.
5. Power failure test.

B. Observation of Test: Give 14 days' advance notice of tests and provide access for Owner's representative to observe tests at Owner's option.

C. Report test results. Include the following data:

1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
3. List of instruments and equipment used in factory tests.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment will be installed before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION
   A. Attach central battery inverter system to wall according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 26 Sections "Hangers and Supports" and "Vibration and Seismic Controls."
   B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 CONNECTIONS
   A. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams, unless otherwise indicated.
   B. Ground equipment according to Division 26 Section "Grounding and Bonding."
   C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION
   A. Identify equipment and components according to Division 26 Section "Electrical Identification."

3.5 FIELD QUALITY CONTROL
   A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
   B. Inspection and Tests:
         a. Follow-up thermographic survey shall not be required.
         b. Prepare test and inspection reports.
      2. Tests and Inspections:
         a. Inspect interiors of enclosures for integrity of mechanical and electrical connections, component type and labeling verification, and ratings of installed components.
         b. Test manual and automatic operational features and system protective and alarm functions.
         c. Test communication of status and alarms to remote monitoring equipment.
         d. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specifications. Certify compliance with test parameters.
         e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 STARTUP SERVICE
   A. Engage a factory-authorized service representative to perform startup service.
   B. Verify that central battery inverter is installed and connected according to the Contract Documents.
C. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 26 Sections.

D. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING AND CLEANING
   A. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.8 DEMONSTRATION
   A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain central battery inverters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 263323
SECTION 263363 – HIGH SPEED ROTARY UNINTERRUPTIBLE POWER SUPPLY (RUPS) SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Provide a rotary uninterruptible power supply (UPS) system as described herein that provides uninterruptible power to critical electrical loads within specified tolerances during failure or deterioration of the normal power supply. The UPS system shall consist of UPS modules, energy storage cabinets (flywheels, batteries), automatic non-interruptive bypass, static switch bypass in parallel with the standard bypass, and other features described in this specification.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include data on features, components, ratings, and performance.

B. Shop Drawings:
   1. Layout Drawings: Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
   2. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. Warranties: Sample of special warranties.
   2. Manufacturer Certificates: For each product, from manufacturer.
   3. For qualified testing agency.

B. Factory Test Reports: Comply with specified requirements.

C. Field quality control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For UPS units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
   2. Cabinet Ventilation Filters: One complete set(s).
1.7 QUALITY ASSURANCE

A. The UPS shall be tested at the factory for proper operation. The UPS assembly shall be functionally tested, and the flywheels shall be burned in for a minimum of 48 hours. Copies of the factory test report and quality control program documentation shall be provided on request.

B. The UPS assembly shall be listed and labeled by UL in accordance with the requirements of UL 1778. All other Equipment shall be listed and labeled in accordance with the applicable UL requirements.

C. UPS shall design and construction shall conform to the following standards as applicable:
   1. UL1778, Standards for Uninterruptible Power Supply Equipment.
   2. UL1004, Standards for Motor Generator Equipment.
   3. FCC Rules and Regulations 47, Part 15, Subpart J, Class A.
   6. NEC.
   7. OSHA safety standards for electrical equipment and service of electrical equipment.

D. The assembly shall be new and of current design and manufacture.

E. Technicians performing all specified services shall be trained, certified and authorized by the manufacturer. They shall be primarily employed to service the manufacturer’s equipment.

F. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
   2. General Electrical Field Quality Control.


1.8 WARRANTY

A. The manufacturer shall warrant the UPS assembly against defect in workmanship and materials for two (2) years from date of delivery to the initial end user.
   1. Include 24/7 on site repair and replacement labor with 4 hour maximum response time from receipt of call.
   2. Include flywheel chamber mineral oil replacement and vacuum regeneration procedures to assure chamber recharging.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following UPS and flywheel partners:
   1. Eaton Corporation (Powerware).
   2. Mitsubishi Electric Power Products Inc..
   3. Pillar Group (Active Power).
   4. Schneider Electric (APC).

HIGH SPEED ROTARY UNINTERRUPTIBLE POWER SUPPLY (RUPS) SYSTEM
2.2 GENERAL CONSTRUCTION

A. All materials used shall be new, of current manufacture, high quality, free from defects and shall not have been in previous use except as required for factory testing.

B. All UPS assembly, except for any remote annunciation panels, remote EPO panels or computer monitoring equipment, shall be free-standing NEMA 1 construction or IEC equivalent. Remote annunciation panels and remote EPO panels shall be wall mounted.

C. Cable access shall be permitted from the top or bottom using raceway or conduit without modification.

D. Construction of the assembly shall facilitate lifting and rigging. Clearance shall be provided in the base of Equipment to allow lifting by forklift from the front or rear. Means shall be provided to lift the assembly by crane without damage. The installing or rigging contractor shall provide appropriate slings spreader bars.

E. All wiring shall be in accordance with NFPA 70, OSHA, and EN. All power conductors, transformer and choke windings shall be copper. All bus bar connections shall be between copper, silver-plated copper or tin-plated copper surfaces and shall be between like metals. Connections shall be properly torqued.

F. All control wiring interconnections between shipping splits of a single piece of the assembly shall be supplied and fitted with connectors or fanning strips constructed and identified to prevent incorrect connection.

G. All field control wiring terminations shall be made to terminal blocks or appropriate receptacles for plug-in connections. Receptacles shall have appropriate restraints to prevent plugs from loosening.

H. All power interconnections between shipping splits of a single piece of the assembly shall be supplied and equipped with termination or connection hardware.

I. All components shall be marked at the field replacement level with the part designations shown on the assembly drawings and parts lists. Label all terminal blocks and other wiring termination means with a designation for the termination location and individual termination point within the location.

J. PCBs shall not be used nor shall any components be used that require toxic or hazardous materials documentation for transportation.

2.3 UPS ASSEMBLY

A. UPS System Components: Each UPS system shall consist of the following main components:

1. One integrated system bypass module (ISBM) and three or more internal uninterruptible power modules (UPM’s). The ISBM includes a Static Bypass and associated Control and Monitor Panel, and each UPM includes a Rectifier, Inverter, and Charger.

B. UPM Modes of Operation: Each UPM shall operate as an on-line, fully automatic system in the following modes:

1. Normal: Utilizing commercial AC power, the critical load shall be continuously supplied by the Inverter. The Inverter shall power the load while regulating both voltage and frequency. The Rectifier shall derive power from the commercial AC source and shall supply DC power to the Inverter.

2. Flywheel: Upon failure of the commercial AC power, the critical load shall continue to be supplied by the Inverter, which shall obtain power from the flywheels without any operator intervention. There shall be no interruption to the critical load upon failure or restoration of the commercial AC source.

3. Recharge: Upon restoration of the AC source, the Charger shall recharge the flywheel and simultaneously the Rectifier shall provide power to the Inverter. This shall be an automatic function and shall cause no interruption to the critical load.

4. Bypass: If the UPM must be taken out of the Normal mode for overload, load fault, or internal failures, the static bypass switch shall automatically transfer the critical load to the commercial AC power. Return from Bypass mode to Normal mode of operation shall be automatic. No break transfer to and from Bypass mode shall be capable of being initiated manually from the front panel.

5. Energy Saver: The UPS shall continuously monitor the voltage and frequency of the bypass source. When the source parameters are within acceptable limits, the UPS will utilize a minimal/optimal combination of its internal subsystems to ensure acceptable power is always delivered to the critical load, at a system efficiency of 99% or greater, over the range of 10% to 100% load. The Energy Saver System shall be enabled by the user, and shall be adjustable. It shall incorporate a “High Alert Mode” to automatically (without user intervention) provide maximum power conditioning any time bypass source variation levels exceed preset, adjustable limits. When Energy Saver System is utilized, the UPS must attenuate ANSI C62.41-type line transients to within IEC and ITIC limits. The Energy Saver System shall be able to distinguish between upstream (utility) faults and downstream (load) faults, and react appropriately to protect and support the critical load, without interruption.

C. Three or more UPM’s, each consisting of:

1. Rectifier/Charger: Each rectifier/charger shall convert incoming AC power to regulated DC output for supplying the inverter and for charging the flywheel. The rectifier/charger shall be a high-frequency PWM design, using Insulated Gate Bi-polar Transistors (IGBTs). The modular design of the UPS shall permit safe and fast removal and replacement of the rectifier/charger module. Mean time to repair (MTTR) for the module shall be no more than 30 minutes in order to return UPS to normal mode. The rectifier/charger module shall also provide the following:
   a. The rectifier shall be capable of drawing power from the utility with a power factor of 0.99 under nominal conditions.
   b. The rectifier shall feature protection circuitry that prevents the IGBTs from sourcing current in excess of their published ratings.

2. Inverter: Each inverter shall feature an IGBT pulse-width-modulation (PWM) design with high speed switching. The inverter shall also have the following features:
   a. The inverter shall be capable of providing the specified quality output power while operating from any DC source voltage (rectifier or flywheel) within the specified DC operating range.
b. The modular design of the UPS shall permit safe and fast removal and replacement of the inverter module. Mean time to repair (MTTR) for the module shall be no more than 30 minutes in order to return UPS to normal mode.

c. The inverter shall feature protection circuitry that prevents the IGBTs from sourcing current in excess of their published ratings.

D. ISBM (Integrated System Bypass Module) section with Static Bypass: The bypass shall serve as an alternative source of power for the critical load when an abnormal condition prevents operation in normal mode. The bypass shall consist of a fully rated, continuous duty, naturally commutated static switch for high-speed transfers. The bypass shall feature the following transfer and operational characteristics.

1. Transfers to bypass shall be automatically initiated for the following conditions:
   a. Output overload period expired.
   b. Critical bus voltage out of limits.
   c. Internal over temperature period expired.
   d. Flywheel discharge.
   e. UPS failure.

2. Uninterrupted automatic retransfer shall take place whenever the inverter is capable of assuming the critical load.

3. Uninterrupted automatic retransfers shall be inhibited for the following conditions:
   a. When transfer to bypass is activated manually or remotely.
   b. In the event of multiple transfers/re-transfer operations the control circuitry shall limit "cycling" to three (3) operations in any ten-minute period. The fourth transfer shall lock the critical load on the bypass source.
   c. UPS failure.

4. Uninterrupted manual transfers shall be initiated from the control panel. Uninterrupted manual transfers to bypass and from bypass shall be possible with the inverter logic. During manual transfers to bypass mode, the inverter must verify proper bypass operations before transferring the critical load to the bypass.

5. All transfers to bypass shall be inhibited for the following conditions:
   a. Bypass voltage out of limits (+/- 10% of nominal)
   b. Bypass frequency out of limits (+/- 3 Hz, adjustable, factory set)
   c. Bypass out of synchronization
   d. Bypass phase rotation / installation error

6. Static Transfer Time: No break, complete in less than 4ms.
7. The bypass shall be manually energized using the control panel or remotely through a building alarm input.

E. Monitoring and Control Components: The following components shall provide monitor and control capability:

1. Control panel with status indicators.
2. Alarm and metering display.
4. Communication ports.

F. Wiring Terminals: The UPS module shall contain mechanical compression terminals (adequately sized to accommodate 90°C wiring) for securing user wiring to the following locations:

1. Rectifier/charger input connections (3-wire plus ground)
2. Bypass input connections (4-wire plus ground for 4-wire plus ground output configuration (480Vac).
3. DC link connections for flywheel cabinets (positive and negative).
4. AC output connections (4 wires plus ground).

G. UPS System Configuration Features:

1. UPS Configurations for Capacity and Redundancy: UPS shall be constructed such that multiple internal UPM’s can be combined for redundancy or capacity. Internal Uninterruptible Power Modules (UPM’s) shall be capable of being paralleled to increase system power levels or to provide redundant power. Up to 3 or 4 internal UPM’s shall be capable of parallel operation, either for capacity or redundancy. The UPS shall have intelligence to automatically recognize the need for capacity and/or redundancy. The UPS shall utilize autonomous internal UPM’s that do not rely on any control interconnections for synchronized operation. The internal UPM’s shall operate in a peer-to-peer manner to provide automatic load sharing, synchronization, and selective tripping capabilities. “Master-slave” configurations are not acceptable.

2. The UPS shall utilize a communications network to provide system information and status, such as operating mode and meter data. This network shall provide individual internal UPM information as well as total UPS information, and shall be available from the UPS front panel display. The loss of this system information network shall not cause the UPS to transfer to bypass or drop the critical load.

3. The UPS’s shall be inherently redundant when the load is less than:
   a. 66% of the UPS rated capacity on UPS systems 650 KVA or above. Under load conditions less than 66% of rated UPS capacity, at least one internal UPM shall be redundant.

4. Concurrent maintenance: Any redundant internal UPM can be concurrently isolated and serviced (by factory-trained service engineers) while the other internal UPM continues to provide protected power to the load.
   a. Provide number of redundant UPMs as required to maintain UPS rating during routine maintenance procedures (Vacuum pump, bearings, oil, etc.).

H. Communication Interface: Provide a communications interface between the UPS module and Building Automation System (BAS). This shall allow the unit to be monitored remotely over an Ethernet network.

1. Communications Protocols:
   a. BACNet.
   b. SNMP.

I. DC Flywheel Cabinets:

1. Flywheel runtime with 3 second rectifier ramp-in time plus the times listed for each UPS shall be a minimum of 10 seconds at 80% full load and 0.9 output power factor.
2. The DC Flywheel and associated support systems shall be capable of storing and delivering up to 300 kW of power or 3,000 kW-s of energy to the UPS DC bus at a nominal voltage 520 VDC or greater. The DC Flywheel shall operate in the following modes:
a. Ready to Start Mode - When the DC Flywheel is initially powered on, it shall enter the Ready to Startup Mode and commence to draw vacuum on the DC flywheel until the minimum vacuum level is met. Once the minimum vacuum level has been met, the system shall magnetically levitate its rotating group and notify the user that the system is ready to transition to Start-up Mode. A manual user command will make the system transition from Ready to start mode to Start-up mode.

b. Start-Up Mode - In Start-up mode, the DC Flywheel shall begin to charge (increase speed) up to the minimum operating speed (0% Available Energy (AE)), power shall be drawn from the UPS system DC bus to accelerate the rotor. When the minimum operating speed is reached, the DC Flywheel shall automatically enter the CHARGE Mode. The DC Flywheel shall be in Start-up Mode as long as 1) the flywheel speed is less than minimum operating speed; and 2) the UPS system DC bus voltage is greater than or equal to the DC Flywheel Charging Voltage Threshold. In Start-up Mode, the DC Flywheel shall not be capable of supporting the UPS DC bus.

c. Charging Mode - To charge the DC Flywheel, power shall be drawn from the UPS system DC bus to accelerate the rotor provided the voltage on the DC bus is within acceptable limits (equal to or above the charging voltage threshold). The charge rate shall be limited so that it does not exceed a UPS manufacturer’s specified input rectifier current or charging current rating. In this Mode, the DC Flywheel’s AE shall progressively increase from 0% to 100%. The DC Flywheel will be in CHARGE Mode as long as: 1) the DC Flywheel’s AE is between 0% and 100%; and 2) the UPS system DC bus voltage is greater than or equal to the DC Flywheel Charging Voltage Threshold. While in CHARGE Mode, the DC Flywheel shall be capable of providing power to the UPS DC bus.

d. Ready Mode - The DC Flywheel shall be in READY Mode when it reaches its maximum operating (“fully charged”) speed. While in READY Mode, the DC Flywheel shall continue to receive a very small amount of power from the UPS system DC bus to maintain a AE > 99.5%. While in READY Mode, the DC Flywheel shall be capable of supporting the UPS DC bus.

e. Discharging Mode - When a voltage sag or failure of the utility AC power source results in a reduction of voltage on the UPS system DC bus, the DC Flywheel enter the Discharging mode and supply power to the critical load by maintaining a pre-set voltage level on the DC bus. The DC Flywheel shall be in the Discharging mode until the DC bus voltage rises (when the AC power returns) or until the DC flywheel reaches its minimum operating speed.

f. Flywheel Shutdown Mode – In Shutdown Mode the DC Flywheel cannot provide energy to the UPS DC bus. A Shutdown process is initiated after a system discharge when the flywheel speed reaches the minimum operating speed and the UPS system DC bus voltage is less than the DC Flywheel Charging Voltage Threshold. A user shall also be able to command the DC Flywheel to transition to Shutdown Mode. While in Shutdown Mode, the user may command a change to Startup or Charge mode provided all required operating parameters are satisfied. System Faults will also initiate a Shutdown.

 g. System Parameters Elevated Mode – In this mode, an error has been detected waiting to be cleared. The flywheel shall continue to operate normally unless the error is further elevated beyond acceptable limits. Errors elevated beyond acceptable limits shall result in a transition to Flywheel Shutdown Mode.

h. Emergency Power Off – The DC Flywheel enters this mode after the local Emergency Shutdown button has been depressed or the Remote Emergency contact has been activated. User intervention is required for the system to be removed from this mode.
J. Maintenance Bypass Module:

1. The Maintenance Bypass Module (MBM) shall provide an alternate electrical path for continuous support of the critical load when servicing or testing the UPS module. This alternate path can be accessed only while the UPS module is in Bypass Mode. This synchronizes the internal UPS Bypass Input with the MBS Output, allowing a safe transfer of Bypass Power to the critical load.

2. The MBM shall be contained in a floor-mounted, enclosed cabinet containing a Maintenance Isolation Breaker (MIS) and Maintenance Bypass Breaker (MBP). UPS Bypass Input Breaker (BIB) shall be available for reverse transfer applications. Each breaker frame utilizes a microprocessor based overcurrent protective trip system. The trip system includes adjustable long time function for overload protection and adjustable instantaneous function for short circuit protection.

3. The MBM shall be ANSI 61 grey.

4. Electronic Interlocking shall be standard on all MBSs. The electronic interlocking feature or the use of Kirk Key type interlocking the separate sources could be paralleled risking the electrical support to the critical load.

5. All released MBM models shall be UL Listed to comply with UL 891 Standards

2.4 UNINTERRUPTIBLE POWER SUPPLY RATINGS AND OPERATING CHARACTERISTICS

A. Ratings. The UPS shall be rated:

1. UPS Rating (max) is the maximum output possible from the UPS (for a load power factor range of 0.9 lagging to 0.9 leading). The UPS shall not require de-rating when supporting a leading power factor load of 0.9 or greater.

B. Rectifier/Charger Input:

1. Operating input voltage range: + 10%, - 15% of average nominal input voltage without flywheel discharge; Voltage tolerance, partial load: -30% of nominal voltage without discharging the flywheel at loads less than 85%.

2. Operating input frequency range shall be 45 to 65Hz.

3. Input power factor 0.99

4. Normal input current limit: The UPS shall have the following programmable input current limit settings while operating in normal mode:

   a. Rectifier/charger input current limit shall be adjustable from 100 to 115% of full-load input current.

   b. Input current limit shall be adjustable from 10% to 15% of the UPS full load input current regardless of the actual load on the UPS.

5. On generator input current limit: The UPS shall have the following programmable input current limit settings while operating in normal mode on generator:

   a. Rectifier/charger input current limit shall be adjustable from 100% to 115% of full-load input current.

   b. Flywheel recharge input current limit shall be adjustable from 10% to 15% of the UPS full load input current regardless of the actual load on the UPS.

6. Input current total harmonic distortion (THD) shall be less than 5.0%. Provide a line reactor or a passive filter to assure reduction of harmonic distortion. Refer to IEEE 519 for specific performance requirements for control of harmonic frequencies.

7. Power walk-in: Ramp-up to full utility load adjustable from 1 seconds to 3 seconds.
C. Rectifier/Charger Output:
1. Nominal DC voltage shall be 480VDC.
2. Steady state voltage regulation shall be +/- 0.5%.
3. Voltage ripple shall be less than 0.5% (peak-to-peak).
4. Capacity: The rectifier/charger shall support a fully loaded inverter and recharge the Flywheel to 90% of its full capacity within 10 times the discharge when input current limit is set at maximum.
5. Low line operation: The rectifier/charger shall be capable of sharing the DC load with the flywheel when the input voltage falls below the specified operation input voltage range, the on flywheel indicator shall enunciate operation in this mode.
6. DC sensing: Redundant DC voltage sensing methods shall be incorporated for providing flywheel over-voltage protection.
7. Flywheel charger characteristics: The UPS flywheel charging system shall have the following characteristics:
   a. The charger shall be capable of being configured for several charge modes including:
      1) A charging mode that increases flywheel life by allowing the flywheel to rest, reducing positive plate corrosion
      2) A charging mode floating the flywheel at a set level, which can be adjusted via software, used for flooded cell applications
         a) Nominal Float Voltage: 2.25 V per cell.
         b) Equalizing Voltage: 2.38 V maximum per cell (adjustable).
         c) Automatic (time based) or manual (user initiated) equalization available.
   b. UPM will automatically adjust flywheel shutdown based upon loading and flywheel capacity.
      1) The UPM shall automatically adjust the final discharge voltage between 1.67 and 1.75 Volts per cell based on the existing load and the rate and length of discharge.
      2) The absolute minimum operational voltage is 1.67 V per cell (adjustable).
8. The UPM will automatically disconnect the flywheel system in case of flywheel discharge followed by prolonged utility AC voltage failure. The time window before flywheel disconnection occurs shall be programmable for both time and voltage.

D. UPS Output in Normal Mode:
1. Steady-state voltage regulation (in inverter) shall be within +/- 1% average from nominal output voltage.
2. Transient voltage response shall be < +/- 5% from nominal voltage for load step from 10% to 100%.
3. Linear load harmonic distortion capability: Output voltage THD of less than 2% for 100% linear load.
4. Non-linear load harmonic distortion capability: Output voltage THD of less than 5% for 100% non-linear load when tested using the non-linear load described in IEC 62040-3.
5. Manual output voltage adjustment shall be +/- 3% from nominal.
6. Line synchronization range shall be +/- 3Hz, adjustable to +/- 0.5Hz.
7. Frequency regulation shall be +/- 0.005Hz free running.
8. Frequency slew rate shall be 1 Hz/second maximum (adjustable).
9. Phase Angle Control:
   a. Balanced linear load shall be +/- 1 degree from nominal 120 degrees.
   b. Unbalanced linear loads shall less than +/- 3 degrees from average phase voltage for 100% load unbalance.

10. Phase Voltage Control:
    a. Balanced linear loads shall be +/- 1% from average phase voltage.
    b. Unbalanced linear loads shall be less than +/- 5% for 100% load unbalanced.

11. Overload current capability (with nominal line and fully charged flywheel): The unit shall maintain voltage regulation for up to 110% of resistive/inductive load for 10 minutes, up to 125% for 30 seconds, and up to 150% for 10 seconds.

12. Fault clearing current capability: 200% RMS for 300ms.

13. Static transfer time: No break, completed in less than 4ms.

14. Acoustical noise: Noise generated by the UPS under normal operation shall not exceed 80dbA at one meter from any operator surface, measured at 25 degrees C (77 degrees F) and full load.

15. EMC Suppression: The UPS shall meet IEC 62040-2, EN50091 Class A restricted limits

16. Electrostatic discharge (ESD): The UPS shall meet EN 61000-4-2 level 3.

17. Efficiency: The UPS efficiency shall be up to 94.5%.

E. UPS Output with Energy Saver System:

1. The Energy Saver System acts to optimize the internal components of the UPS power train to maximize system efficiency when the bypass source is within the following (adjustable) limits: Voltage: +/-10%, and Frequency: +/-3Hz.

2. Steady-state voltage regulation (in inverter) shall be within +/- 10% from nominal output voltage.

3. Line synchronization range shall be +/- 3Hz, adjustable to +/- 5Hz.

4. Frequency regulation shall be +/-3Hz when bypass source is within limits in (1) above; +/-0.005Hz free running.

5. Overload current capability (with bypass source within the limits of (1) above) 1000% for 20msec, 600% for 50 ms.

6. Static transfer time: No break, completed in less than 2ms.

7. Acoustical noise: Noise generated by the UPS under normal operation shall not exceed 75dbA at one meter from any operator surface, measured at 25 degrees C (77 degrees F) and full load.

8. EMC Suppression: The UPS shall meet IEC 62040-2, EN50091 Class A restricted limits

9. Electrostatic discharge (ESD): The UPS shall meet EN61000-4-2 level 3.

10. Efficiency: The UPS efficiency shall be up to 99% over the range of 10 to 100% load. Manufacturer shall state efficiency of UPS with input filters for controlling input THD connected.

2.5 MECHANICAL DESIGN

A. Ventilation: The UPS shall be designed for forced-air cooling. Air inlets shall be on the front of the unit. Air outlets shall be on the top. Eighteen inches of clearance over the UPS outlets shall be required for proper air circulation.

B. No back or side clearance or access shall be required for the system. The back and side enclosure covers shall be capable of being located directly adjacent to a wall.
C. Cable Entry: Standard cable entry for the UPS cabinet shall be through either the enclosure bottom or top. A dedicated wireway shall be provided within the UPS cabinet for routing user input and output wiring.

D. Front Access: All serviceable subassemblies shall be modular and capable of being replaced from the front of the UPS. Side or rear access for installation, service, repair or maintenance of the UPS system shall not be required.

E. Service Area Requirements: The system shall require no more than thirty-six (36) inches of front service access room and shall not require side or rear access for service or installation.

2.6 INPUT TRANSFORMER

A. An input transformer shall be included when scheduled on Drawings. The transformer shall be a 480V delta to 480Y/277V wye configuration. Factory install transformer inside the UPS assembly cabinet. Transformer ratings:
   1. DOE 2016 efficiency requirements.
   2. 150 degrees C temperature rise.

2.7 CONTROLS AND INDICATORS

A. Microprocessor controlled circuitry: The UPS controls shall have the following design and operating characteristics:
   1. Fully automatic operation of the UPS shall be provided through the use of microprocessor controlled Digital Signal Processing. DSP shall eliminate variances from component tolerance or drift, and provide consistent operational responses.
   2. All operating and protection parameters shall be firmware controlled, thus eliminating a need for manual adjustments. The logic shall include system test capability to facilitate maintenance and troubleshooting. Printed circuit board replacement shall be possible without requiring calibration.
   3. Start-up and transfers shall be automatic functions.

B. Digital Front Panel Display: The UPS control panel shall be a digital front panel display that features an 8x40 (8 lines, each with 40 characters) backlit LCD display. The LCD shall display UPS status, metering, flywheel status, alarm/event queue, active alarms and UPS configurations. The front panel display shall show a system mimic diagram with an outlined power path, current operating mode and event logs.

C. Control Panel Indicators: The UPS control panel shall provide the following monitoring functions with indicator LED’s:
   1. NORMAL: This shall indicate that the commercial AC utility or generator source is supplying power to the rectifier and the inverter is supporting the critical load. A text message shall indicate if the bypass line is not within tolerance.
   2. BYPASS: This shall indicate that the UPS has transferred the load to the bypass circuit.
   3. FLYWHEEL: This shall indicate that the commercial AC utility or generator source has failed and the flywheel is supplying power to the inverter, which is supporting the load.
   4. ALARM: This shall indicate that the UPS detects an alarm condition, outlined in detail in the operator’s manual.

D. Control Panel Controls: The UPS control panel shall provide the following functions from front panel push buttons:
1. EVENTS: Displays the list of Active System Events and a historical log of system events. Historical logs shall include a detailed time stamped list of the latest 128 events.

2. METERS: Displays performance meters for the system or critical load. When selected, the front display shall show individual screens of input parameters, output parameters or bypass parameters including; voltage, current and frequency. In addition, the flywheel display shall show runtime remaining.

3. CONTROLS: Displays a System Controls screen. Allows selection of operating mode, normal, bypass, charger on/off and Power Module on/off.

4. SETUP: Allows display contrast, date and time information serial communication port configuration and display of firmware revision numbers.

5. RETURN: Confirms selection or returns to previous screen.

E. Interface Panel: The UPS shall be equipped with an interface panel, located behind a protective cover, which provides the following signals and communication features in a Class 2 environment:

1. Alarm Contact: A dry contact for annunciating a summary alarm shall be provided for customer use. This contact shall be Form "C" capable of supplying both N/O and N/C contacts. Contact ratings shall be 5A max at a voltage not to exceed 28VDC or 277VAC.

2. RS232 (EIA / TIA-232) communications interface: Circuitry shall be provided for one RS232 (EIA / TIA-232) communication port for connection to automated service department diagnostic tools. This port may be used with simple ("dumb") terminals to gain remote access to all unit operation information.

3. Building Alarms: Two inputs shall be provided for monitoring the status of external dry contacts. Building alarms shall be set up through the UPS configuration mode function on the RS232 (EIA / TIA-232) port.

4. External EPO Contacts: Shall be provided to connect an external remote emergency power off switch to shutdown the UPS and de-energize the critical load.

5. Flywheel Control Contacts: Contacts shall be provided to connect the flywheel shunt trip and auxiliary signals from a flywheel breaker.

6. External Bypass Indicator Connection: A connection point shall be provided to acknowledge that an external maintenance bypass has been closed around the UPS, placing the critical load on utility power.

7. The system shall have options to add four (4) additional building alarms, 384 logged events, 4 additional languages, English or Arabic as a primary language.

2.8 ENERGY STORAGE SYSTEM, LITHIUM ION BATTERIES

A. System Characteristics:

1. Battery Cabinet:
   a. Each battery cabinet shall contain paralleled strings of battery modules. Cabinets may be paralleled for additional runtime.
   b. Each cabinet shall contain a DC disconnect breaker with appropriate auxiliary contacts for interface with the UPS module.

2. Battery Modules:

3. Battery Monitoring System:
   a. The ESS shall have a hierarchical set of control systems consisting of the following:
      1) Cell Monitoring Unit (CMU) – cell-level battery monitoring contained on each module.

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2) Battery Management Unit (BMU) – string-level battery management contained in each enclosure in the system.

3) Host Controller – system-level management which communicates with the UPS and transmits pre-defined information to the customer’s BAS.

B. System Control and Indicators:

1. Mode Indicators:
   a. The following Modes shall be displayed:
      1) Ready to Start: No system faults the system can be started.
      2) Starting-up: System is in start-up mode, DC Bus is pre-charging.
      3) Charging: Battery are storing to its fully charged state.
      4) Ready (Full Charge): Battery is fully charged, ready for discharge.
      5) Discharging: Battery is discharging, supplying power to the DC bus.
      6) System Parameters Elevated: System has entered a condition waiting to be cleared. If the condition persists or is further elevated, the system will enter the Battery Shutdown mode.
      7) Battery Shutdown: System entered a condition resulting in a shutdown. This may be user or system initiated.
      8) Emergency Power Off: The local emergency shutdown button has been depressed or the Remote emergency contact has been activated.

2. Parameters:
   a. The following parameters shall be available to be displayed:
      1) DC Bus Current, Amps.
      2) DC Bus Power, Kw.
      3) DC Bus Voltage, VDC.
      4) DC Isolation Contactor Status.
      5) Enclosure Temperature Status.
      6) Battery System Hours.
      7) Housing Temperature Status.
      8) Number of Discharge Events.
      9) Power Supply Status.

3. Warnings and Alarms:
   a. The following warnings and alarms shall be displayed when the Warning/Alarm Events screen is accessed.
      1) DC Bus Isolation Contactor.
      2) Emergency Power Off.
      3) Enclosure Temperature.
      4) High DC Voltage.
      5) Low DC Voltage.
      6) Precharge Contactor.
      7) Precharge Timeout.
      8) Remote EPO.
      9) System Alarm.
     10) User Stop Initiated.

C. UPS System Cabinet Interface:
1. The battery shall be able to be monitored by UPS via communications devices. Battery manufacturer shall provide interface devices capable of communicating via various industry-standard protocols. Monitoring of battery status shall be performed by UPS through isolated dry contact Form C relays.

2.9 ENERGY STORAGE SYSTEM, FLYWHEELS

A. General Materials:

1. All materials of the DC Flywheel shall be new, of current manufacture, high grade and free from all defects and shall not have been in prior service except as required during factory testing. The maximum working voltage, current and di/dt of all solid-state power components and electronic devices shall not exceed 75% of the ratings established by their manufacturer. The operating temperature of solid-state component sub-assembly shall not be greater than 75% of their ratings. Electrolytic capacitors shall be computer grade and be operated at no more than 95% of their voltage rating.

B. Wiring:

1. Wiring practices, materials and coding shall be in accordance with requirements of the national Electrical Code (NFPA 70). All bolted connections of busbars, lugs and cables shall be in accordance with requirements of the National Electrical Code and other applicable standards. All electrical power connections are to be torqued to the required value and marked with a visual indicator.

C. Construction and Mounting:

1. The DC Flywheel shall be housed in a freestanding cabinet with a NEMA 1 construction rating or IEC equivalent. No space is required between the back or sides of the cabinet and any walls. The DC Flywheel shall accommodate bottom (standard) or top (optional) access entry for control and power cables. The DC Flywheel shall be able to be rolled into place and go through a standard 36-inch-wide (915mm) door.

2. The DC Flywheel shall be cleaned, primed and painted with the manufacturer's standard color. The DC Flywheel shall be constructed of replaceable subassemblies. Printed circuit assemblies shall be plug connections. Like assemblies and like components shall be interchangeable.

D. Maintenance Access:

1. The front clearance of 36 in. (0.9m) per the National Electrical Code is required. No side or rear access shall be required for any service. Access to all components shall be from the front and top.

E. Cooling:

1. The DC Flywheel stator and power electronics shall be air cooled with no requirements for liquid cooling. The DC Flywheel package shall be designed for natural and forced air-cooling. Air inlets shall be provided from the bottom front of the DC Flywheel enclosure. Air exhaust shall be from the top of the unit. For air ventilation, a 12 in. (0.3m) minimum clearance overhead is required.

F. Grounding:

1. The DC Flywheel shall have an equipment ground terminal such as to be able to be effectively grounded to the frame of the interconnected UPS system.
G. Components:

1. UPS Interconnection:
   a. The DC Flywheel shall enable physical interconnection to a UPS system. The interconnection shall include a disconnect-switch and system controls configured for operation with specific UPS systems.

2. Power Conversion Module:
   a. The Power Conversion Module shall be a 3-phase IGBT bridge converter capable of sourcing or sinking power to and from the UPS DC bus. While providing energy to the DC Bus of the UPS, the Power Conversion Module shall convert "variable frequency - variable voltage" AC power from the motor-generator and deliver regulated DC voltage to the UPS DC bus. Conversely, during rotor acceleration to store energy, the Power Conversion Module shall convert DC power from the UPS DC Bus into "variable frequency - variable voltage" AC power to the motor-generator.

3. Controllers:
   a. The system consists of two (2) controllers, a master controller and a magnetic bearing controller that provide the overall control of the DC Flywheel. The controllers’ functions are described herein.

   1) Master Controller:
      a) The Master Controller shall provide the overall control of the DC Flywheel as well as the specific control for the motor-generator and the power conversion module. The Master Controller shall be powered from the protected AC output of the UPS.
      b) The Master Controller shall use microprocessor-controlled logic. All operation and parameters shall be firmware controlled. The logic shall include a self-test and diagnostic circuitry such that most faults can be identified. Diagnostics shall be performed via a PC through the RS232 communication port or through the Control Panel located on the front of the DC Flywheel.

   2) Magnetic Bearing Controller:
      a) The magnetic bearing controller shall provide the overall control of the active magnetic bearing hardware. The controller shall continuously monitor the flywheel and provide control signals to the magnetic bearings to keep the flywheel centered and levitated. The magnetic bearing controller shall accept both AC power and DC power. It shall normally be powered from the protected AC output of the UPS. In the event of failure of the protected AC output, the magnetic bearing controller shall keep the rotating group levitated by employing the backup DC critical power supply.
      b) The Magnetic Bearing Controller shall use DSP logic. All operation and parameters shall be firmware controlled, thus eliminating the need for manual adjustments. The logic shall include a self-test and diagnostic circuitry such that most faults can be identified.
4. Flywheel Module:
   a. The Flywheel Module shall house several major components: a) Rotating Group; b) Permanent Magnet Motor-Generator; and c) the 5-axis active magnetic bearing.
      1) Rotating Group (Rotor/Flywheel):
         a) The flywheel shall be made of Aerospace grade high strength steel and shall be integrated with the motor/generator shaft to operate as a single rotating group. The rotating group shall be magnetically levitated and centered so that the rotating group does not touch any other part while in normal operation. No mechanical bearings shall be required while operating under normal conditions. There shall be no coils on the rotor; no brushes shall be employed.
   b. Permanent Magnet Motor-Generator:
      1) The rotating group shall be positioned within the stator in such a way that the rotor and stator can provide the motor generator function of the DC Flywheel. Stator cooling shall be accomplished via conductive transfer of heat to the flywheel housing and shall operate within a housing in which air has been evacuated. Together the stator and rotor shall operate as a permanent magnet motor-generator and shall be capable of producing enough power to the output DC bus up to 300kW or 3000 kW-S of energy and capable of a charge/discharge cycle every fifteen minutes indefinitely.
   c. 5-Axis Active Magnetic Bearing:
      1) The flywheel system shall utilize homopolar permanent magnet bias active magnetic bearings to suspend the rotor. Two (upper and lower) magnetic bearings shall provide three axes of support, responding to static and dynamic forces to keep the rotor suspended and centered.

5. Vacuum Pump:
   a. A vacuum pump shall be integrated with the system and evacuate the flywheel housing so as to provide and maintain a vacuum level less than 35 mTorr during the normal operation of the DC Flywheel. The pump discharge shall be to ambient atmosphere.

6. Control Panel:
   a. The DC Flywheel shall use an interactive LCD Control Panel as the primary means for an operator to interface with the system with an optional touchscreen control panel PC as a secondary means. The LCD Control Panel shall indicate operating parameters listed in this section. The Control Panel shall be menu driven and provide access to warning and fault information.

7. Mode Indicators:
   a. The following Modes shall be displayed:
      1) Ready to Start: No system faults the system can be started.
      2) Starting-up: System is in start-up mode, DC Bus is pre-charging.
      3) Charging: Flywheel is accelerating to its fully charged state.
      4) Ready (Full Charge): Flywheel is fully charged, ready for discharge.
      5) Discharging: Flywheel is discharging, supplying power to the DC bus.
6) System Parameters Elevated: System has entered a condition waiting to be cleared. If the condition persists or is further elevated, the system will enter the Flywheel Shutdown mode.

7) Flywheel Shutdown: System entered a condition resulting in a shutdown. This may be user or system initiated.

8) Emergency Power Off: The local emergency shutdown button has been depressed or the Remote emergency contact has been activated.

8. Parameters:
   a. The following parameters shall be available to be displayed:
      1) DC Bus Current, Amps.
      2) DC Bus Power, Kw.
      3) DC Bus Voltage, VDC.
      4) DC Isolation Contactor Status.
      5) Enclosure Temperature Status.
      6) Flywheel Speed, % Operating Speed.
      7) Flywheel System Hours.
      8) Housing Temperature Status.
      9) Inverter Temperature Status.
     10) Magnetic Bearing Status.
     11) Number of Discharge Events.
     12) Power Supply Status.
     13) Pre-charge Contactor Status.
     14) Vacuum Level, mTorr.

9. Warnings and Alarms:
   a. The following warnings and alarms shall be displayed when the Warning/Alarm Events screen is accessed.
      1) DC Bus Isolation Contactor.
      2) Emergency Power Off.
      3) Enclosure Temperature.
      4) High DC Voltage.
      5) IGBT Temp. Phase A.
      6) IGBT Temp. Phase B.
      7) IGBT Temp. Phase C.
      8) Low DC Voltage.
      9) Magnetic Bearing Failure.
     10) Precharge Contactor.
     11) Precharge Timeout.
     12) Remote EPO.
     13) System Alarm.
     14) User Stop Initiated.
     15) Vacuum Level Warning.
     16) Vacuum Level Fault.

H. UPS System Cabinet Interface:
   1. The flywheel shall be able to be monitored by UPS via communications devices. Flywheel manufacturer shall provide interface devices capable of communicating via various industry-standard protocols. Monitoring of flywheel status shall be performed by UPS through isolated dry contact Form C relays.
I. OPERATIONAL REQUIREMENTS

1. No bearing replacement shall be required over the life of the DC Flywheel under normal operating conditions. In order to regenerate the vacuum within the operating specifications, an annual vacuum pump oil change shall be required under normal operating conditions. The procedure to change the oil (Regenerate the vacuum) shall not require the DC flywheel system to be taken off-line and should be able to be completed within 10 minutes. The DC flywheel energy storage system must be able to support a discharge while the procedure is being performed if required. The inlet air filter in the cabinet will need to be replaced as required given the environmental conditions at the installation site.

2.10 COMMUNICATIONS

A. Communications Bay: The UPS shall be equipped with field configurable communications bays that will accommodate four (4) communication devices.

B. Remote Monitoring:

1. The UPS shall be able to be monitored remotely via communications devices. UPS manufacturer shall provide communications devices capable of communication via various industry-standard protocols.
   a. Communication Protocols:
      1) BACNet.
      2) SNMP.

2. The UPS communication capability should be able to integrate into any industry standard Building Management System (BMS) and/or Network Management System (NMS). The UPS must also be able to be monitored via any standard Internet browser (i.e. Internet Explorer, Chrome, or Firefox).

3. All remote monitoring interfaces shall be "Hot-swappable" (UPS maintains power to critical applications while changing interfaces).

C. Remote Monitoring Parameters: UPS shall communicate the following values:

1. Program the following alarms:
   a. Output Amp Over User Limit (PhsA-B-C combined, User Limit threshold at ____ A).
   b. Battery Low Shutdown
   c. Battery Low (low battery threshold at 50%).
   d. Output Load on Maintenance Bypass.
   e. Battery Discharging.
   f. System Output Off.
   g. General Alarm (all other system alarms).

2. Program the following Status:
   a. Battery Charging.
   b. System Status.
   c. UPS Output Source.

3. Program the following inputs:
   a. System Output Nominal Voltage.
   b. System Output Power.
   c. DC Bus Current.
D. Notification:
   1. There shall be a mechanism to send alerts to key personnel via email or SNMP traps. An alarm notification may also be sent by a network message.

2.11 UPS PROTECTION
A. Rectifier/Charger and Bypass protection shall be provided through fusing.
B. Flywheel protection shall be provided by thermal-magnetic molded-case circuit breakers in each flywheel cabinet (if standard flywheel pack is provided) or external protective device for an external flywheel.
C. Electronic current limiting circuitry and fuses in the Inverter circuit shall provide output protection.
D. To comply with agency safety requirements, the UPS shall not rely upon any disconnect devices outside of the UPS to isolate the flywheel cabinet from the UPS.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install UPS components on concrete bases.
   1. Anchor UPS components to concrete bases according to manufacturer’s written instructions, seismic codes at Project, and requirements in Division 26 Sections “Hangers and Supports”.
B. Maintain minimum clearances and workspace at equipment according to manufacturer’s written instructions and NFPA 70.

3.2 FIELD QUALITY CONTROL
A. Inspection and Tests:
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS "Emergency Systems, Uninterruptible Power Systems", Sections for rotary hybrid uninterruptible power supply system components, "System Functional Tests", and "Thermographic Survey" requirements and the following additional requirements.
   a. Follow-up thermographic survey shall not be required.
   b. Prepare test and inspection reports.
   c. Factory trained field service personnel are required to be present for testing and may require they lead the hands-on testing to meet warranty requirements.
   d. All testing shall be in the presence of the Owner’s designated representative.
   e. Visual Inspection:
      1) Verify sizing and connection of neutral and ground conductors.
      2) Verify that all circuit boards are configured and mounted correctly.
      3) Verify the installation conforms to manufacturer’s drawings and installation requirements.
      4) Verify that all optional hardware and software is installed and tested.
   f. Electrical Inspection:
      1) Verify all fuse continuity.
2) Verify input voltages and bypass voltages correspond to the assembly rating.
3) Verify phase rotation of inputs and bypass.
4) Verify connection of current transformers, and control power transformers.
5) Verify correct input and bypass voltage.
6) Verify current UPS control wiring and terminations.
7) Verify voltage of battery modules.
8) Verify neutral and grand conductors are properly sized and configured.
9) Inspect external maintenance bypass switch for proper terminations and phasing.

g. Endurance Test:
1) Test each UPS at 100 percent rating to full discharge state with an appropriately sized load bank.
   a) Confirm useful output time for each system.
   b) Confirm recharge time to 100 percent capacity.
2) Conduct thermographic survey during test.

h. Perform the following checks as part of system start-up:
1) Energize control power circuits and verify all control voltages.
2) Verify correct firmware revision.
3) Check operation of control logic and verify correct software set-RUPS.
4) Start the assembly.
5) Verify FES starts and charges properly.
6) Energize the module output. Verify BDC operation correct output voltage regulation and proper phase rotation.
7) Verify that no alarm conditions exist.
8) Verify all indications, Notices, Alarms, and metering functions operate properly and are calibrated.
9) Verify operation of all options. In particular verify that if a modem is installed it is connected to telephone lines and communicate correctly. Set modem telephone numbers and parameters in RUPS software.

i. Perform the following tests and simulations:
1) Simulate input power failure and verify FES discharge and recharge. Verify that operation alarms and indications are correct.
2) Manually transfer the system to bypass and return. Verify correct transfer and operation of all indications and alarms.

END OF SECTION 263363
SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes transfer switches rated 600 V and less, including the following:

1. Automatic Transfer Switches (ATS):
   a. Isolation By-Pass Transfer (IBTS) Switches.
   b. Closed Transition Transfer Switches (CTTS).


3. Transfer Switch Remote Annunciator System.

4. Transfer Switch Remote Annunciator and Control System.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1. Final transfer switch approval subject to approved Division 26 Protective Device Coordination study.

1.3 ACTION SUBMITTALS

A. Product Data: Submit wiring diagrams, manufacturers catalog sheets, and rating data including the following:

1. Transfer Switch Data:
   a. Contactor manufacturer confirmation.
   b. Catalog cut sheets.
   c. Withstand and close-in ratings.
   d. Operating and maintenance instructions.
   e. Complete control and power wiring diagrams.
   f. Certified test results on identical switches.
   g. Access requirements to isolation by-pass type switches.

B. Shop Drawings:

1. Layout Drawings: Provide room equipment layout drawings assuring proper clearances.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. Source Quality Control Test Reports:
   a. Certified summary of prototype unit test report.
   b. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
   d. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
   e. Report of sound generation.
2. Warranty: Special warranty specified in this section.
3. Qualification Data: For Installer, Manufacturer and Testing Agency

B. Field Quality Control Test Reports.

1.5 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Features and operating sequences.
   2. List of all factory settings of relays; provide relay setting and calibration instructions, including software, where applicable.

1.6 CODES AND STANDARDS
A. DHHS (HRS-M-HF) 84-1.
B. IEEE Orange Book.
C. NEC Article 250, 445, and 695.
D. NEC Article 700, 701 and 702.
E. NFPA 99, Health Care Facilities.
G. NFPA 110, Emergency and Standby Power Systems for Level 1 emergency power supply system.
H. UL 1008, Standard for Automatic Transfer Switches.

1.7 PROJECT CONDITIONS
A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Construction Manager and Owner no fewer than fourteen (14) days in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without Construction Manager's or Owner's written permission.

1.8 QUALITY ASSURANCE
A. Manufacturer Qualifications:
   1. Manufacturer: The transfer switches and all major items of auxiliary equipment shall be manufactured in the United States by manufacturers currently engaged in the production of such equipment. The equipment shall be standard factory produced units, factory assembled and tested and shipped to the job site by the engine generator assembler or his authorized dealer having a parts and service facility in the area.
   2. Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.
B. Source Limitations: Obtain transfer switch equipment through one source from a single manufacturer.

TRANSFER SWITCHES

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C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Warranty:
   1. Submit with the drawing submittals, written warranty by the transfer switch manufacturers for a period of two (2) years or 1500 operating hours, whichever occurs first, covering 100 percent of defective materials and labor. Multiple warranties for individual components will not be acceptable. The warranty period shall begin upon acceptance of the installation by the Owner.

E. Assembly Selection: The Drawings indicate sizes, profiles, and dimensional requirements of engine generator sets and assembly equipment. Equipment having equal performance characteristics and complying with indicated maximum dimensions and profiles may be considered, provided deviations do not change the design concept intended performance, or code/future extension provision clearances. The burden of proof of equality is on the proposer a minimum of 10 days prior to bid.


1.9 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

1.10 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
   2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Transfer Switch Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Basis of Design: Emerson; ASCO Power Technologies, LP.
   2. Russelectric is allowed with owner approval based on the project and location.
   3. Acceptable Equivalents/ Manufacturers as approved by Owner, submit as substitution request per Division 1.

B. The emergency generator control system, associated batteries and battery chargers, and automatic transfer switches shall be supplied by the engine-generator set manufacturer for unit responsibility.

C. Submit proof from the manufacturers of the engine-generator set and transfer switches of qualified service capability, acceptable to the Engineer, in the area where the system will be installed.
2.2 AUTOMATIC TRANSFER SWITCHES (ATS)

A. General:
1. Automatic transfer switches shall consist of a power transfer module and a control module, interconnected to provide complete automatic operation. Automatic transfer switches shall be mechanically held and electrically operated by a single electrical operator energized from the source to which the load is to be transferred. The switch shall be rated for continuous duty and be inherently double throw. The switch shall be mechanically interlocked to ensure only one of two possible positions - normal or emergency, except for switches serving motor loads which are addressed in this Section.
2. The automatic transfer switches shall be rated to withstand the RMS symmetrical short circuit and 3 cycle (or 30 cycle as indicated on drawings) withstand ratings current generally available at the automatic transfer switch terminals with the type of overcurrent protection as scheduled and in conjunction with the approved coordination study.

B. Operation:
1. Each automatic transfer switch shall sense partial or complete loss (less than 85 percent) of normal voltage in any phase. After a time delay of 1 second (adjustable 0.0 to 6 seconds) a starting signal shall be transmitted over a 2-wire circuit to the EGS starting controls.
2. All phases of the normal sources shall be monitored line-to-line. Close differential voltage sensing shall be provided on all phases. The pick-up voltage shall be adjustable from 85 percent to 100 percent of nominal and the dropout voltage shall be adjustable from 75 percent to 98 percent of the pick-up value. The transfer to emergency will be initiated upon reduction of normal source to 85 percent of nominal voltage and retransfer to normal shall occur when normal source restores to 95 percent of nominal on all phases.
3. All phases of the emergency source shall be monitored for voltage and frequency for return to normal if the emergency source becomes unstable. The pick-up voltage shall be adjustable from 85 percent to 100 percent of nominal and set at 90 percent. The pick-up frequency shall be adjustable from 90 percent to 100 percent and set at 57 hertz.
4. For delayed emergency loads, each transfer switch shall have a time delay on transfer to emergency. Initially set at zero but field adjustable up to 2 minutes for controlled timing of load transfer to emergency.
5. When normal power returns, each transfer switch shall, after a time delay, retransfer to "normal" side. The time delay shall be adjustable from 0-30 minutes and set at 30 minutes. If during this period, the generator voltage should fail, each transfer switch shall immediately return to "normal."
6. Generator cool-down shall be provided by a time delay relay providing for unloaded running of the generator for a period of 0 to 10 minutes.
7. Motor load transfer switches shall be factory equipped with the programmed transition feature. This feature shall provide a field adjustable time delay during which time the load is isolated from both power sources, to allow residual voltage of motors or other inductive loads (such as transformers) to decay before completing the switching cycle. The programmed transition feature shall have an adjustable time of 0 to 7.5 seconds. All transfer switches without programmed transition feature shall be capable of addition of the programmed transition feature in the field without transfer switch replacement. Transfer methods that use the phase relationships between the two power sources to control a transfer initiation time are also acceptable in both directions.
C. Materials:

1. Each automatic transfer switch shall be rated for continuous duty when enclosed in a (non-ventilated distribution switchboard or) surface, wall-mounted in NEMA 1 enclosure. It shall be rated for all classes of loads, including inductive and non-inductive at 480 volts, and tungsten lamp at 250 volts. The switch portion shall be designed, built, and tested to close on an in-rush current up to an including 20 times the continuous rating of the switch and rated to close on and withstand a fault current as indicated without welding or excessive burning of contacts.

2. Transfer switches shall meet all provisions of the latest version UL1008.

3. All main contacts shall be silver composition, wiping action type. Switches rated 600 amperes and above shall have separately removable arcing contacts. The operating transfer time in either direction shall not exceed one-sixth (1/6) of a second.

4. All control module relays, timers, control wiring, and accessories shall be front accessible. Inspection of all contacts (movable and stationary) shall be possible from the front of the enclosure without disconnection of drive linkages or power conductors. All control wires shall be terminated with tubular sleeve type markers or be permanently marked on both ends. Control modules shall be:
   a. Manufacturer’s front accessible LCD/keypad programmable microprocessor-based design meeting requirements herein.
   b. Coordinated to match existing automatic transfer switch control units.
   c. Hardwired through each automatic transfer switch for external control connections. Software based interconnection to common monitor/control contacts are not acceptable.

5. Automatic transfer switches utilizing components of molded-case circuit breakers are not acceptable. Automatic transfer switches utilizing contactors, or part thereof which have not been intended for continuous duty or repetitive load transfer switching are not acceptable.

6. Transfer switches containing neutral conductors shall be provided with a fourth pole for neutral switching as scheduled on Drawings. The fourth pole must have the same short circuit and withstand ratings as the main poles.

7. The short circuit, withstand and close in capability shall meet or exceed the ratings scheduled on Drawings for all poles of a three or four pole switch when operating at rated voltage.

8. Each Transfer Switch shall have:
   a. An enclosure with internal copper ground bar with lugs for incoming ground wires.
   b. Provisions for electrically disconnecting the control section from the transfer section to permit safe access for maintenance or service during periods of normal operation.
   c. Front Panel Devices: Provide devices mounted on front of main cabinet door consisting of switch position indicator lamps: normal (white), emergency (red), normal source available (green), emergency source available (red), and toggle switches to provide the following positions and functions:
      1) Test - Simulated normal power loss to control unit for testing of generator set, including transfer of load. Controls shall include provisions to automatically return the system to the normal power source if the generator set fails during any test or exercise period.
      2) Normal - This is a normal operating position and it restores the load to the normal source after test and after time delays.
      3) Retransfer - Momentary position to over-ride retransfer time delay and cause immediate return to normal source after test or actual outage. (This feature may be push-button activated).
d. **In-phase Monitor Transfer feature:** Provide in-phase monitors on all automatic switches except for delayed transition switches. Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 10 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources area within 2Hz of nominal frequency and 70% or more of nominal voltage.

e. **Terminal blocks with identification of all external connections,** cross-referenced to the schematic wiring diagram.

f. **A laminated engraved nameplate on the front of the enclosure,** carrying its designation.

g. **For other than bypass/isolation type transfer switches,** a UL listed manual operator shall be provided in accordance with UL1008, arranged so that the transfer switch can be manually operated under load without opening the enclosure door. The manual operator shall provide the same contact-to-contact transfer speed as the electrical operator to prevent a flashover from switching the main contacts slowly. Failure to comply with this requirement shall require contractor to supply and coordinate an isolation/bypass type transfer switch installation at no cost to Owner.

D. **Accessories:**

1. Exercise timer to start generator set and transfer load on transfer switch having closest proximity to associated generator set. Set timer to run generator for 25 minutes under load and 5 minutes unloaded.
2. Start contacts for the engine control shall be gold type, dry contacts wired to easy access terminal block and compatible with the generator set control equipment furnished.
3. Two normally opened and two normally closed auxiliary contacts rated 10 amps, 250 volts, 60 hertz, AC (for remote monitoring of the switch position).
4. Operation Counter.
5. Preferred source selection switch for non-emergency applications of the ATS, located inside the switch cabinet.
6. Connectivity Module to allow remote monitoring of transfer switch power meter and control functions via serial or Ethernet connections.
7. Alarm output to the BAS indicating ATS in maintenance (bypass) mode or not in normal state.
8. Provide other accessories as scheduled on Drawings.

E. **Power Monitor:**

1. Furnish Power Monitors at locations shown to monitor all functions specified below.
2. The Power Monitors shall be listed to UL 3111-1, CSA, CE Mark, and industrially rated for an operating temperature range of -20°C to 60°C.
3. The Power Monitor shall be accurate to 1% measured, 2% computed values and display resolution to .1%. Voltage and current for all phases shall be sampled simultaneously to assure high accuracy in conditions of low power factor or large waveform distortions (harmonics).
4. The Power Monitor shall be capable of operating without modification at nominal frequencies of 45 to 66 Hz and over a control power input range of 20 – 32VDC.
5. Each Power Monitor shall be capable of interfacing with an optional communications module to permit information to be sent to central location for display, analysis, and logging.
6. The Power Monitor shall accept inputs from industry standard instrument transformers (120 VAC secondary PT’s and 5A secondary CTS.) Direct phase voltage connections, 800 VAC and under, shall be possible without the use of PT’s.
7. The Power Monitor shall be applied in single, 3-phase, or three & four wire circuits. A fourth CT input shall be available to measure neutral or ground current.

8. All setup parameters required by the Power Monitors shall be stored in nonvolatile memory and retained in the event of a control power interruption.

9. The following metered readings shall be communicated by the Power Monitor, via serial or ethernet communication:
   a. Current, per phase RMS and neutral (if applicable)
   b. Current Unbalance %
   c. Voltage, phase-to-phase and phase-to-neutral
   d. Voltage Unbalance %
   e. Real power (KW), per phase and 3-phase total
   f. Apparent power (KVA), per phase and 3-phase total
   g. Reactive power (KVAR), per phase and 3-phase total
   h. Power factor, 3-phase total & per phase
   i. Frequency
   j. Accumulated Energy, (MWH, MVAH, and MVARH)

10. The following energy readings shall be communicated by the Power Monitor:
   a. Accumulated real energy KWH
   b. Accumulated reactive energy KVAH
   c. Accumulated apparent energy KVARH

11. The Power Monitor shall flush mount to an enclosure.

12. The Power Monitor shall be furnished with a Modbus gateway device to permit remote monitoring of all parameters via the BAS.

13. The Power Monitors shall be equipped with an optional continuous duty, long-life, 4 line x 20 character LCD backlit display to provide local access to the following metered quantities:
   a. Current, per phase RMS and neutral (if applicable)
   b. Current Unbalance %
   c. Voltage, phase-to-phase and phase-to-neutral
   d. Voltage Unbalance %
   e. Real power, per phase and 3-phase total
   f. Apparent power, per phase and 3-phase total
   g. Reactive power, per phase and 3-phase total
   h. Power factor, 3-phase total & per phase
   i. Frequency
   j. Accumulated Energy, (MWH, MVAH, and MVARH)

14. Displaying each of the Power Monitor quantities shall be accomplished through the use of menu scroll buttons.

15. For ease in operator viewing, the display shall remain on continuously, with no detrimental effect on the life of the Power Monitor.

16. Setup for system requirements shall be allowed from the front of the Power Monitor. Setup provisions shall include:
   a. CT rating (xxxxx: 5)
   b. PT rating (xxxxxxx:120) (if applicable; 24000V maximum)
   c. System type (single; three phase; 3 and 4 wire)
   d. Communication parameters
17. Reset of the following electrical parameters shall also be allowed from the front of the Power Monitor:
   a. Real energy (MWH), apparent energy (MVAH) and reactive energy (MVARH).

18. All reset and setup functions shall have means for protection against unauthorized/accidental changes.

F. Isolation/By-Pass Capability:

1. Automatic transfer switches in this facility shall be the isolation/bypass (IBTS) type as shown on Drawings. The IBTS configuration will allow either the normal or the emergency source to be connected directly to the load to allow the normal automatic transfer switch to be isolated and deenergized for maintenance, testing, or repair. Permanently mounted external operating handles shall be used. Positive mechanical interlocks shall prevent source to source interconnections. Bypass contacts shall be make-before-break or break-before-make, quick-make, quick-break with the operating mechanism, load-break capability and electrical ratings identical to the main automatic transfer switch. The automatic transfer switch shall be full drawout construction with no need for any electrical or mechanical disconnections. The IBTS configuration shall operate as a manual transfer switch when the ATS is removed. The IBTS switch shall be fully mechanical and not dependent upon relays, interlocked circuits, separate contactor or operator dependent timing for safe operation. Other features:
   a. All bus interconnections shall be silver plated.
   b. All operating handles shall be permanently attached.
   c. Provide two sets of auxiliary contacts, each for remote monitoring of switch placed in normal bypass and emergency bypass modes for associated front cover pilot lights and remote monitoring. Provide associated pilot lights for each made of operation. One set of contacts shall be for future customer use.

G. Closed-Transition Switching Capability:

1. Froedtert’s standard is closed transition switches.

2. The transfer switch shall be of the closed-transition transfer switch (CTTS) type to transfer the load in a make-before-break action between the utility and standby generating system sources. Both sources shall be connected to the load, in phase, for a maximum period of 100 milliseconds through the use of an in-phase monitor. This operation shall not alter the speed or require active control of the emergency generator sets. The transfer shall occur only when the two sources are within +/- 5 electrical degrees maximum and +/- 5% maximum voltage differences to limit generator synchronizing currents.

3. A fail-safe feature to force the 2nd available source open and signal an alarm condition shall be made in the event closed transition (opening of the original source) does not occur within the 100 millisecond time limitation. Operation of this feature shall require manual reset.
   a. If both operators should fail simultaneously while their contacts are both closed, a dry contact shall closet to shunt trip remote source protective devices.

4. Local Electrical Utility Co. approval of the specific CTTS for this project must be accompanied with Shop Drawing submission prior to acceptance.

5. Closed-Transition shall only be permitted where all downstream distribution equipment is adequately rated for the combined short circuit contribution from both sources.

H. Load Shedding:
1. Each automatic transfer switch shall be classified by priority according to the type of load they serve (Priority 1, 2, 3, 4) requiring special functional characteristics. Also, transfer switches feeding motor loads will differ from those feeding non-inertia loads. Refer to transfer switch schedule on Drawings for identification of functions required, as well as for voltage and current rating and current withstand rating.

2. Load Limit Operations:
   a. Each automatic transfer switch of Priority 2, 3, or 4, shall be permitted to transfer to "emergency" only when the permissive circuit from the Paralleling Switchgear System is closed.
   b. There shall be no such restrictions on re-transfer to "normal."

3. Load Shed Operations:
   a. Each automatic transfer switch of Priority 2, 3, or 4, when in "emergency" position, shall transfer to an "open" or "normal" position if the permissive circuit opens.
   b. If the switch has transferred to "open" position, and if normal 3-phase power returns, the switch shall transfer to "normal" position without time delay.
   c. Each switch of Priority 2, 3, or 4, shall have an additional pilot light indicating "load shed" position.

I. Tests:

1. Certified independent laboratory test data on a switch of the same design and rating shall be provided to confirm the following switching abilities:
   a. Overload and endurance per Tables 21.2 and 23.2 of UL1008 when enclosed according to Paragraph 1.6.
   b. Temperature rise tests after the overload and endurance tests to confirm the ability of the transfer switches to carry their rated current within the allowable temperature limits of the insulation in contact with current-carrying parts.
   c. No welding of contacts. Transfer switch must be operable by the normal means after the withstand current tests.
   d. Dielectric tests at 1960 Volts, RMS, minimum after the withstand current test, per UL1008.

2. All transfer switches shall be subjected to the following factory tests:
   a. The complete automatic transfer switch shall be tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.
   b. The complete automatic transfer switch shall be subjected to a dielectric strength test per NEMA Standard ICS 1-109-05.
   c. The control panel shall meet or exceed the voltage surge withstand capability in accordance with IEEE Standard 472-1974 (ANSI C37.90a-1974) and the impulse withstand voltage test in accordance with NEMA Standard ICS-1-109.

2.3 MANUAL TRANSFER SWITCHES (MTS)

A. Manual (or non-automatic) transfer switches shall comply with all requirements of automatic transfer switches except:

1. MECHANICALLY/HELD MANUALLY OPERATED: Operation shall be by non-removable external manual handle, operable only with door closed.
2. Manual transfer switches shall be provided with quick-make, quick-break switching action mechanisms with no passes or intermediate position stops during switching sequence.
3. Manual transfer switches shall not initiate a generator start sequence or have front panel toggle switches.
4. Pilot lights on front panel shall indicate switch position: Normal (white), emergency (red), normal source available (green), emergency source available (red).

2.4 TRANSFER SWITCH REMOTE ANNUNCIATOR AND CONTROL SYSTEM

A. Functional Description: Include the following functions for transfer switches:
   1. Indication of sources available, as defined by actual pickup and dropout settings of transfer switch controls.
   2. Indication of switch position.
   3. Indication of switch in test mode.
   4. Indication of failure of digital communications link.
   5. Key switch or user code access to control functions of panel.
   6. Control of switch test initiation.
   7. Control of switch operation in either directions
   8. Control of time delay bypass for transfer to normal source.

B. Malfunction of annunciator, annunciation and control panel, or communications link shall not affect functions of transfer switch. In the event of failure of the communications link, transfer switch automatically reverts to standalone, self-contained operation. Transfer switch sensing, controlling or operating function shall not depend on remote panel for proper operation.

C. Remote Annunciation and Control Panel: Solid state components. Include the following features:
   1. Controls and indicating lights grouped together for each transfer switch.
   2. Label each indicating light control group. Indicate the transfer switch it controls, location of the switch and the load it serves.
   3. Digital Communications Capability: Matched to that of transfer switches supervised.
   5. Lamp Test: Lamp test switch on panel front.
   6. Power Source: Generator sets best battery.

D. The ATS shall report out to the BAS system and alarm if it is not in normal state.

E. Remote Monitoring Parameters: Transfer Switch shall communicate the following values:
   1. Program the following alarms:
      a. Source 1 Failure
      b. Source 2 Failure
      c. Transfer Source 1 to Source 2
      d. Load Shed Active.
      e. General Alarm (all other system alarms).
   2. Program the following Status:
      a. Source 1 Status.
      b. Source 2 Status.
      c. ATS Status.
      d. ATS in Bypass on Source 1.
      e. ATS in Bypass on Source 2.
      f. Generator Start Signal.
3. Program the following Inputs:
   a. Real Power.
   b. Current Time Length on Source 2.

2.5 SOURCE QUALITY CONTROL
   A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section “Vibration and Seismic Controls.”
   B. Install transfer switch(es) where shown.
      1. Anchor floor mounted transfer switches to 4 inch concrete base and attach by bolting.
   C. Maintain minimum clearances and workspace at equipment according to manufacturer’s written instructions and NFPA 70.
   D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets and temporary blocking of moving parts from transfer switch units and components.
   E. Equipment branch switches shall have a connection to the BAS system and programmed to provide a pre-transfer signal to the equipment being served.
   F. Switches serving elevators shall be have a connection to the elevator control panel as required by the elevator manufacturer.

3.2 COORDINATION
   A. Coordinate together with equipment suppliers and other Divisions, their equipment operational voltages and controls for proper generating system operation including all new (and existing) engine generator sets and transfer switches. Provide any necessary auxiliary equipment shall provide for, but not be limited to:
      1. Engine start, paralleling switchgear control system, remote annunciator(s) and transfer switch relays and controls. Include existing automatic transfer switch and EGS interfaces/interconnects.
      2. Proper access about IBTS type automatic transfer switches.
      3. Remote EGS annunciator interconnection.
      4. Wiring and programming necessary to connect new transfer switches into existing Transfer Switch Monitoring system.

3.3 MANUFACTURER’S SUPERVISION
   A. Provide manufacturer’s field labor for supervision, testing, Owner operating personnel training and instructions and related services during installation.
   B. Obtain a signed statement from the service representative for the transfer switches that the installation is acceptable before the first start up. A copy of the statement shall be submitted to the Engineer.

TRANSFER SWITCHES
3.4 FIELD QUALITY CONTROL

A. Inspection and Tests – General:
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS Sections "Emergency Systems, Engine Generator", Emergency Systems, Automatic Transfer Switches" Sections for other emergency power systems components, "System Functional Tests", and "Thermographic Survey" requirements and the following additional requirements:
      a. Follow-up thermographic survey shall not be required.
      b. Prepare test and inspection reports.
      c. Prior to acceptance of the installation, in addition to the factory test, the equipment shall be field tested to show it is free of any defects and will start automatically and be subjected to full load test. To accomplish the field load test, be responsible for providing the necessary load banks as a part of this Contract.

B. Inspections and Tests – Transfer Switches:
   1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
      a. Check for electrical continuity of circuits and for short circuits.
      b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers and safety features.
      c. Verify that manual transfer warnings are properly placed.
   3. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
      a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
      b. Simulate loss of phase-to-ground voltage for each phase of normal source.
      c. Verify time-delay settings.
      d. Verify pickup and dropout voltages by data readout or inspection of control settings.
      e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
      f. Perform contact-resistance test across main contacts and correct values exceed 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
      g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdowns.
   4. Perform complete and partial outages wing transfer switches. Observe availability of generator power to emergency loads and branches ensuring load and control functions are commonly energized.
   5. Ground Fault Tests: Coordinate with testing of ground fault protective devices for power delivery from both sources.
      a. Verify grounding connections and locations and ratings of sensors.
      b. Observe reaction of circuit-interrupting devices when simulated fault current is applied at sensors.
6. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

7. Test each transfer switch operationally by opening the "normal" source, to insure proper load transfer, and to insure that all control and monitor signals are properly transmitted.
   a. Verify proper elevator control signaling.
   b. Provide auxiliary contacts in the switch to:
      1) Indicate switch position at Generator Control System.

C. Provide nameplates per Division 26 Section "Electrical Identification."

END OF SECTION 263600
SECTION 264113 - LIGHTNING PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes lightning protection for buildings and building elements.

1.2 SYSTEM DESCRIPTION
   A. Additions to Buildings and Structures: Protect entire building (or structure) including roof projections, chimneys, exhaust stacks, vents, antennas, roof-mounted equipment, ladders, cranes, cooling towers and equipment or structures adjacent to the building. Modify existing lightning protection system so additions to roof mounted equipment, etc., are protected. For equipment removals and similar modifications ensure that main roof conductors are continuous and have at least two horizontal and downward paths to connections at the counterpoise. When equipment is added to roofs and protected such that nearby air terminals now fall within the zone of protection of the new items, remove the older items and insure the cross leads and down leads remain serviceable.

1.3 DEFINITIONS
   A. LPI: Lightning Protection Institute.
   B. NRTL: National Recognized Testing Laboratory.

1.4 SUBMITTALS
   A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.5 ACTION SUBMITTALS
   A. Product Data: For each type of product specified, including roof adhesive where used.
   B. Shop Drawings:
      1. Layout Drawings: Provide scale drawings and details of the complete system including, but not limited to:
         a. Location of lightning protection air terminals.
         b. Size and location of all conductors.
         c. Methods of attachments.
         d. Location, size and type of ground electrodes.
         e. Schematic diagram of the complete system (standard diagrams will not be acceptable).

1.6 INFORMATIONAL SUBMITTALS
   A. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by an NRTL or LPI.
      1. Installer
      2. Manufacturer
   B. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply membrane roofing material.
1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described in subparagraphs below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spare Air Terminals: Provide not less than three (3) spare air terminals including bases and mounting hardware/cable connectors.

1.8 CLOSEOUT SUBMITTALS

A. Record Documents:

1. Final field layout record drawings.
2. UL Lightning Protection Inspection Certificate indicating the system has been inspected by a UL representative and has been approved by UL without variation.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who is an NRTL or who is certified by LPI as a Master Installer/Designer.

B. Listing and Labeling: As defined in NFPA 780, “Definitions” Article.

C. NFPA and UL Compliance: Comply with requirements of NFPA Standard 780, and UL Standard 96 as applicable to lightning protection systems for building projects. Protected coverage shall include penthouse, entire roof area of the building, and equipment installed on roof.

D. UL Compliance: Comply with UL Standards 96 and 96A.

E. ANSI Compliance: Comply with applicable requirements of ANSI Standard C2.

F. Field Testing: Refer to Division 26 Section “Electrical Inspections and Testing” for field inspections and testing requirements related to this Section including:

1. Electrical Acceptance Testing Responsibilities
2. General Electrical Field Quality Control
3. Testing Agency Qualifications

1.10 COORDINATION

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Approved Lightning Protection, Co., Inc.
2. Crowley Lightning Protection, Inc.
3. East Coast Lighting Equipment.
4. ERICO International Corporation.
5. Independent Protection Co.
7. Robbins Lightning, Inc.
8. Thompson Lightning Protection, Inc.

2.2 GENERAL
A. Provide lightning protection system materials and components that comply with manufacturer's standard design, in accordance with published product information. Provide air terminals, bonding plates, conductors, connectors, conductor straps, fasteners, grounding plates, grounding rods, rod clamps, splicers and other components required for a complete system that meets NFPA 780 standards and UL 96.
B. Type of metal for air terminals and cables: Copper or aluminum.
C. Type of Down Conductor: Copper or aluminum down conductor, or structural steel
D. Copper materials shall not be mounted on aluminum surfaces including Galvalume, or galvanized steel or zinc; this includes these materials that have been painted.
E. Aluminum materials shall not come into contact with earth of where rapid deterioration is possible. Aluminum materials shall not come into contact with copper surfaces.

2.3 AIR TERMINALS
A. Air terminals shall be 1/2 inch minimum diameter solid copper or 5/8 inch minimum diameter aluminum with blunt tips and shall extend at least 12 inches above the object to be protected. All air terminal bases shall be cast copper with stainless steel bolt-pressure cable connectors.
   1. Base for flat roofs or equipment mounting and shall be suitable for appropriate mounting to roofing materials.
   2. Spring type air terminals shall not be used.

2.4 MAIN ROOF INTERCONNECTING AND DOWN CONDUCTORS
A. Minimum UL listed strands of 15 gauge copper wire weighing 375 lbs. per 1000 feet with 115,000 CM cross section, installed according to UL Code.
B. Minimum UL listed strands of 13 gauge aluminum wire weighing 190 lbs. per 1000 feet with 192,000 CM cross section, installed according to UL Code.

2.5 INDIVIDUAL METALLIC ROOFTOP BUILDING EQUIPMENT BONDING CONDUCTORS
A. Minimum UL listed strands of 17 gauge copper wire of 26,240 CM cross section, installed according to NFPA 780.
B. Minimum UL Listed strands of 14 gauge aluminum wire of 41,100 CM cross section, installed according to NFPA 780.

2.6 FASTENERS
A. Conductor fasteners shall be an approved type of non-corrosive metal and shall have sufficient strength to support conductors.

2.7 CONNECTORS
A. Accessible conductor connectors shall be cast aluminum or copper or electro tin plated bronze with screw-pressure type stainless steel bolts and nuts.
B. Inaccessible, including underground installations, conductor connectors shall be made using a molded fusion welding process, equal to Cadweld, using proper mold and the number, size and type cartridge for the connection.

2.8 GROUND RODS
A. As specified in Division 26 Section "Grounding and Bonding."

2.9 CONDUIT
A. Minimum Schedule 40 PVC as specified in Division 26 Section "Raceways."
B. Air Terminals for roof mounting: Provide units with bases especially designed for roof materials.

PART 3 - EXECUTION

3.1 INSTALLATION OF LIGHTNING PROTECTION SYSTEMS
A. Install lightning protection systems as described herein, in accordance with equipment manufacturer’s drawings, written instructions, and in compliance with applicable installation standards specified above.

B. Install the system, including air terminals, conductors, and complementary parts, so that completed work is unobtrusive and does not detract from the building appearance.

C. Coordinate air terminal and conductor locations with window washing equipment supplier. Perimeter air terminals shall be spaced at maximum of 20 feet. Maintain equal spacing.

D. Install conductors with direct paths from air terminals to ground connections avoiding sharp bends and narrow loops. Run concealed interior conductors in non-metallic raceway, Schedule 40, minimum. Fasten cable and/or conduit on maximum three foot centers.

E. Structural steel used as main and down conductors shall meet the requirements of NFPA 780 and UL 96A.

F. Conceal all down conductors and install in 1-1/2” minimum schedule 40, PVC conduit.

G. Ground connections shall be welded to steel columns at the column base. Ground rod connections to be made at same column as roof down lead conductor column connections.
   1. Ground electrode connections to the ground rod shall be made at a point not less than one foot below grade and at least two feet away from a foundation wall or footing.
   2. Attach ground rod conductors to steel columns at Level 1 with bonding plates having a surface area of not less than 8 square inches which shall be exothermic welded to cleaned areas of the structural columns.

H. Bond the nearest down conductor to the water and gas services on the street side of the associated meters.

I. Splices and Clamps: Use approved molded welded fusion weld connections for all inaccessible (when project completed) conductor splices and all inaccessible (when project completed) and underground connections between conductors and other components. Provide bonding jumper at structural steel grounded column joints.

J. Coordinate and use proper roof flashings at all roof penetrations as recommended by roofer.
K. Metal bodies including roof drains, vent pipes, etc. located within six feet of a lightning conductor shall be connected to the system. Metal bodies also require inter-connection even though they are over six feet from lightning conductor, if they are within six feet of a metal body already connected.

L. All connections which will be inaccessible when the project is completed shall be made using an exothermic welding process equal to Cadweld or Copperweld.

M. Provide miscellaneous bonding to railing, window washing davits, satellite dishes, antennas, etc.

3.2 CORROSION PROTECTION

A. Use no combination of materials that may form an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture, unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist that would cause deterioration or corrosion of conductors, use conductors with suitable protective coatings.

3.3 GROUNDING AND BONDING

A. Provide equipment grounding and bonding connections sufficiently tight to assure permanent and effective grounds and bonds.

3.4 FIELD QUALITY CONTROL

A. UL Inspection: Provide inspections as required to obtain a UL Master Label for system for new stand-alone building systems.

B. For expansion of existing systems, provide certification that the new installation meets all requirements of the a UL Master Label, except it is interconnected with an existing system that is not inspected.

END OF SECTION 264113
SECTION 264313 – SURGE PROTECTION DEVICES FOR LOW VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes a parallel connected surge protection device (SPD) system for low voltage (120 to 600V) power distribution equipment.
B. This section does not include surge arresters and lightning arresters for low voltage and medium voltage duty, which are specified as accessories to substations and switchgear.

1.2 DEFINITIONS
A. $I_{\text{nominal}}$: Nominal discharge current.
B. $MCOV$: Maximum continuous operating voltage.
C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current voltage characteristic.
E. OCPD: Overcurrent protective device.
F. SCCR: Short circuit current rating.
G. SPD: Surge protective device.
H. VPR: Voltage protection rating.
I. TYPE 1 DEVICE: Installed on the line or load side of main overcurrent protective device. Includes all overcurrent protective devices and safety disconnect switches inside SPD.
J. TYPE 2 DEVICE: Installed on the load side of main overcurrent protective device. It may require external overcurrent protective device.

1.3 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.4 ACTION SUBMITTALS
A. Product Data: For each SPD component and accessory specified.
B. Shop Drawings:
   1. Layout Drawings: Including dimensioned plans, sections, and elevations. Show tabulations of installed devices, major features, weights, performance ratings, etc. Include the following:
      a. Enclosure type of NEMA type to match equipment to be protected.
      b. Features, characteristics, ratings and factory settings.
      c. Wiring diagrams detailing differentiating between factory and field installed wiring.
      d. Circuit breaker disconnect product information and location.
      e. Dimensioned room layouts assuring proper NEC clearances and coordination.
f. Equipment manual indicating installation, start-up and operating instructions for the system. The manual shall include information to determine whether the system requires an external overcurrent device in order to maintain the system's UL 1449 3rd Edition listing.

g. UL 1449 Ratings: Documentation of system's UL 1449 3rd Edition listing and VPRs.


i. Warranty information.

j. Fuse time current characteristics and data.

k. UL listing and labeling for lightning protection master label.

2. Factory Quality Control Test Reports.

1.5 INFORMATIONAL SUBMITTALS

A. Special Warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. The SPD shall be warranted for 10 years.

B. Electrical Component Standard: Components and installation shall comply with NFPA 70, "National Electrical Code."

C. UL Compliance and Labeling: Listed per UL 1449 3rd Edition, Type 1 and Type 2 Devices, and UL 1283.


F. NFPA 780, UL 96, and UL 96A Compliance: UL listed and labeled for electric service entrance lightning protection certification. Listing and labeling other than UL is not acceptable to meet UL lightning protection master label.

G. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
   2. General Electrical Field Quality Control.

1.8 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify Construction Manager not less than fourteen (14) days in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Construction Manager's written permission.
B. Service Conditions: Rate surge protection devices for continuous operation under the following conditions, unless otherwise indicated:

1. Operating Temperature: 30 to 120 deg F (0 to 50 deg C).
2. Humidity: 0 to 85 percent, noncondensing.
3. Altitude: Less than 6,600 feet (2000 m) above sea level.

1.9 COORDINATION

A. Coordinate location of field mounted surge suppressors to allow adequate clearances for maintenance.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Basis of Design:
   a. Square-D Surge Logic (Schneider Electric).

2. Acceptable Equivalents/Manufacturers as approved by Owner, submit as substitution request per Division 1.

2.2 SWITCHGEAR SPD CHARACTERISTICS

A. Unit Operating Voltage: The nominal unit operating voltage and configuration shall be as shown on Drawings, but is generally 480Y/277V. UL 1449 3rd Edition – Type 1.

B. Maximum Continuous Operating Voltage (MCOV): The maximum continuous operating voltage (MCOV) of all suppression components utilized in the unit shall not be less than 125 percent of the facility’s nominal operating voltage for 120 volt nominal systems and not less than 115 percent of the facility’s nominal operating voltage for 208, 277, and 480 volt nominal systems.

C. Operating Frequency: The operating frequency range of the unit shall be 47 to 63 Hertz.

D. Protection Modes: The modes of protection shall be line-to-line (phase) line-to-neutral, line-to-ground and neutral-to-neutral.

E. SPD shall be UL listed and labeled for compliance with UL 96A when used in conjunction with a lightning protection system requiring a master labeling.
F. Single and Maximum Repetitive Surge Current Capacity: Based on the ANSI/IEEE C62.41 standard 1.2 x 50 microsecond, 20 KV open circuit voltage and an 8 x 20 microsecond 10 KA Category 3 current waveform, the maximum repetitive surge current capacity, in amps, of the unit shall be no less than as follows:

**Maximum Surge Current Rating**

<table>
<thead>
<tr>
<th>Modes of Protection</th>
<th>L-L (Three)</th>
<th>L-N (Three)</th>
<th>L-G (Three)</th>
<th>N-G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Pulse Surge Current Capacity (Amps)</td>
<td>200,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
</tr>
<tr>
<td>Repetitive Surge Current Capacity (Impulses)</td>
<td>5,500</td>
<td>5,500</td>
<td>5,500</td>
<td>5,500</td>
</tr>
</tbody>
</table>

G. Performance Ratings: The unit’s published performance ratings shall be the UL 1449 3rd Edition (2009) Listed VPR. The maximum UL 1449 3rd Edition (2009) VPR shall be, for each mode of protection, as follows:

**VPR**

<table>
<thead>
<tr>
<th>System Voltage</th>
<th>L-L</th>
<th>L-N</th>
<th>L-G</th>
<th>N-G</th>
</tr>
</thead>
<tbody>
<tr>
<td>208Y/120</td>
<td>1200</td>
<td>800</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>480Y/277</td>
<td>2000</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
</tr>
</tbody>
</table>

H. Fuse Documentation: If the system is fused, the fuses must be capable of allowing the suppressor’s maximum rated transient current to pass through suppressor, as a minimum 1000 times, without fuse operation. If any external current limiting devices are required, those devices shall be detailed and included, its impact on surge current capability and clamping level shall be provided. All overcurrent protection circuits shall be monitored and provide indication of suppression operability failure.

1. Provide complete time current characteristics, let through test data and test documentation establishing coordinate protective function for SPD component.
2. Provide UL listing for fuses utilized in SPD.

I. Provide status LED indicators on front of enclosure indicating that each MOV array in each mode of protection is in full working order.

J. Provide Form-C contact for remote monitoring of protection status by the building BAS. Failure of any surge diversion module or the opening of any current limiting device shall signal monitoring system.

K. Suppression / Filter System:
1. High-Performance Suppression System per ANSI/IEEE C62.41 Category C3: The unit shall include an engineered parallel connected, solid-state high-performance suppression system, utilizing field replaceable arrays of fused non-linear voltage dependent metal oxide varistors (MOV) with similar operating characteristics. The suppression systems components shall optimally share surge currents in a seamless, low-stress manner assuring maximum performance and proven reliability. The suppression system shall not utilize gas tubes, spark gaps, silicon avalanche diodes or other components which might short or crowbar the line, thus leading to interruption of normal power flow to or system upset of connected loads. The suppression system shall not incorporate any other components which may degrade performance or reliability of the suppression system. Suppression response shall be 0.5 nanoseconds or less. The system shall be tested to 3500 sequential ANSI/IEEE C62.41 Category C3 waveforms without failing or degrading the UL 1449 VPR by more than 10 percent.

MCOV Table for MOVs:

<table>
<thead>
<tr>
<th>Voltage</th>
<th>MCOV</th>
</tr>
</thead>
<tbody>
<tr>
<td>120V</td>
<td>150V</td>
</tr>
<tr>
<td>220V</td>
<td>275V</td>
</tr>
<tr>
<td>277V</td>
<td>320V</td>
</tr>
<tr>
<td>480V</td>
<td>640V</td>
</tr>
</tbody>
</table>

2. High-Frequency Extended Range Tracking Filter: The unit shall include a UL 1283 high-frequency extended range tracking filter. The filter shall reduce fast rise-time, high-frequency, error producing transients and electrical line noise to harmless levels thus eliminating disturbances which may lead to system upset.

Filtering Attenuation Table

<table>
<thead>
<tr>
<th>Frequency (KHz)</th>
<th>Attenuation (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>100</td>
<td>50</td>
</tr>
</tbody>
</table>

3. Integral Circuit Breaker for Suppression / Filter System: The unit shall require the associated switchgear, switchboard and distribution panelboard assembly to have an integral circuit breaker as a means of disconnecting the suppression / filter system for maintenance and/or test purposes without interruption of power to the facility’s distribution system. The breaker shall be 3-pole for three-phase applications and shall be padlockable.

4. Suppression / Filter System Components: All internal wiring associated with the suppression / filter system and subject to surge currents shall utilize low-impedance copper bus bar and/or #8 AWG copper conductor or larger. All internal connections associated with the suppression / filter system and subject to surge currents shall be made with compression solderless-type lugs and shall be bolted to the bus bars in order to reduce overall system impedance. No plug-in component modules, quick disconnect terminals or printed circuit boards shall be used in surge current-carrying paths.

2.3 PANELBOARD SPD CHARACTERISTICS

A. Unit Operating Voltage: The nominal unit operating voltage and configuration shall be as shown on Drawings. UL 1449 3rd Edition – Type 2.
B. Maximum Continuous Operating Voltage (MCOV): The maximum continuous operating voltage (MCOV) of all suppression components utilized in the unit shall not be less than 125 percent of the facility’s nominal operating voltage for 120 volt nominal systems and not less than 115 percent of the facility’s nominal operating voltage for 208, 277, and 480 volt nominal systems.

C. Operating Frequency: The operating frequency range of the unit shall be 47 to 63 Hertz.

D. Single and Maximum Repetitive Surge Current Capacity: Based on the ANSI/IEEE C62.41 standard 1.2 x 50 microsecond, 20 KV open circuit voltage and an 8 x 20 microsecond 10 KA Category 3 current waveform, the maximum repetitive surge current capacity, in amps, of the unit shall be no less than as follows:

<table>
<thead>
<tr>
<th>Modes of Protection</th>
<th>L-L (Three)</th>
<th>L-N (Three)</th>
<th>L-G (Three)</th>
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</tr>
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<tr>
<td>Single Pulse Surge Current</td>
<td>100,000</td>
<td>50,000</td>
<td>50,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Capacity (Amps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetitive Surge Current</td>
<td>3,500</td>
<td>3,500</td>
<td>3,500</td>
<td>3,500</td>
</tr>
<tr>
<td>Capacity (Impulses)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

E. Performance Ratings: The unit’s published performance ratings shall be the UL 1449 3rd Edition (2009) Listed VPR. The maximum UL 1449 3rd Edition (2009) VPR shall be, for each mode of protection, as follows:

<table>
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F. Fuse Documentation: If the system is fused, the fuses must be capable of allowing the suppressor’s maximum rated transient current to pass through suppressor, as a minimum 1000 times, without fuse operation. If any external current limiting devices are required, those devices shall be detailed and included, its impact on surge current capability and clamping level shall be provided. All overcurrent protection circuits shall be monitored and provide indication of suppression operability failure.

1. Provide complete time current characteristics, let through test data and test documentation establishing coordinate protective function for SPD component.
2. Provide UL listing for fuses utilized in SPD.

G. Provide status LED indicators on front of enclosure indicating that each MOV array in each mode of protection is in full working order.

H. Provide Form-C contact for remote monitoring of protection status by the BAS. Failure of any surge diversion module or the opening of any current limiting device shall signal monitoring system.

I. Suppression / Filter System:
1. High-Performance Suppression System per ANSI/IEEE C62.41 Category C3: The unit shall include an engineered parallel connected, solid-state high-performance suppression system, utilizing field replaceable arrays of fused non-linear voltage dependent metal oxide varistors (MOV) with similar operating characteristics. The suppression systems components shall optimally share surge currents in a seamless, low-stress manner assuring maximum performance and proven reliability. The suppression system shall not utilize gas tubes, spark gaps, silicon avalanche diodes or other components which might short or crowbar the line, thus leading to interruption of normal power flow to or system upset of connected loads. The suppression system shall not incorporate any other components which may degrade performance or reliability of the suppression system. Suppression response shall be 0.5 nanoseconds or less. The system shall be tested to 3500 sequential ANSI/IEEE C62.41 Category C3 waveforms without failing or degrading the UL 1449 VPR by more than 10 percent.

   MCOV Table for MOVs:
   
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</table>

2. High-Frequency Extended Range Tracking Filter: The unit shall include a UL 1283 high-frequency extended range tracking filter. The filter shall reduce fast rise-time, high-frequency, error producing transients and electrical line noise to harmless levels thus eliminating disturbances which may lead to system upset.

   Filtering Attenuation Table
   
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</thead>
<tbody>
<tr>
<td>100 Khz</td>
<td>40 dB</td>
</tr>
<tr>
<td>1 Mhz</td>
<td>30 dB</td>
</tr>
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<td>35 dB</td>
</tr>
<tr>
<td>100 Mhz</td>
<td>50 dB</td>
</tr>
</tbody>
</table>

3. Suppression / Filter System Components: All internal wiring associated with the suppression / filter system and subject to surge currents shall utilize low-impedance copper bus bar and/or #8 AWG copper conductor or larger. All internal connections associated with the suppression / filter system and subject to surge currents shall be made with compression solderless-type lugs and shall be bolted to the bus bars in order to reduce overall system impedance. No plug-in component modules, quick disconnect terminals or printed circuit boards shall be used in surge current-carrying paths.

4. The SPD shall have a remote enclosure type to match panelboard to be SPD protected and be close-nipped directly to the panelboard.

5. Provide 3-pole, 30A circuit breaker in associated panelboard and #8 AWG conductors to the SPD unit unless required otherwise by SPD manufacturer.

J. SCCR: Equal or exceed 100 KA.

K. I\_nominal: 20 KA.

2.4 IDENTIFICATION

A. General: Refer to Division 26 Section "Electrical Identification" for labeling materials.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Mount service entrance SPD meeting specified requirements and NEC code clearances.

B. Connect switchgear SPD through a circuit breaker type disconnect installed within the assembly for the SPD device or SPD shall be provided with an integral disconnect. Assure padlocking provision of the associated circuit breaker. Provide short and straight lead lengths between the suppressor and associated electrical assembly breaker. Provide SPD conductor per manufacturer’s recommendations but not to exceed 10 feet in total length. Tape leads tightly together to reduce their self-inductance. Size breaker and leads per manufacturer’s recommendations. Make no sharp bends in leads. Install all conductors within the assemblies and/or within interconnecting conduit with grounding bushings.

C. Tighten electrical connectors and terminals, including grounding connections, in accordance with manufacturer’s published torque-tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

D. Assure grounding of the SPD enclosure and shunt tie to equipment ground (not isolated ground).

E. SPDs shall be installed at all:
   1. Life Safety Branch distribution and branch panelboards.
   2. Elevator distribution and branch panelboards.
   3. UPS system distribution and branch panelboards.
   4. Switchgear.
   5. Switchboards.

F. SPDs shall be tied to the BAS system for monitor and alarming of status.

3.2 IDENTIFICATION

A. Install SPD device nameplates per Division 26 Section "Electrical Identification."

3.3 COORDINATION

A. Where multiple SPD devices are supplied for this Project, provide documentation for proper coordinated protection between two (2) or more SPD units in series.

3.4 TESTING

A. Provide completed field inspection and checklist from manufacturer’s representative with certification that unit is installed correctly and operational.

END OF SECTION 264313
SECTION 265100 – INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section provides requirements and specification criteria for the provision of the following:
   1. Interior luminaires, ballasts, lamps and related accessories.
   2. Emergency lighting products.
   3. Illuminated “EXIT” signs.
   4. Luminaire supports.

1.2 DEFINITIONS AND ABBREVIATIONS

A. CCT: Correlated Color Temperature.
B. CRI: Color Rendering Index.
C. CU: Coefficient of Utilization.
E. L(p): Rated Lumen Maintenance: (p) is the remaining percentage of initial lumens produced by an
   LED light source, at the stated time interval, in hours.
   L70 @ 50,000 Hours - 70% of the initial lumens produced, remain after 50,000 operating hours.
   L50 @ 50,000 Hours - 50% of the initial lumens produced, remain after 50,000 operating hours.
F. LED: Light Emitting Diode.
G. LER: Luminaire Efficacy Rating.
H. Luminaire: A complete lighting assembly or product consisting of; not less than a light source(s)
   and related device(s) to position the light source(s), housing or enclosure, light source control,
   optics and shielding, and light source power supply/control device(s).
I. NRTL: Nationally Recognized Testing Laboratory.
J. RCR: Room Cavity Ratio.
K. RoHS: Restriction of the Use of Hazardous Substances in Electrical and Electronic Equipment.
   As used herein, compliance shall be defined as meeting or exceeding the requirements set forth
   in European Union Directive 2002/95/EC.
L. Solid State Lighting/Luminaires: Light sources and their associated luminaires that produce light
   (radiant energy) without the use of electrical filaments, excited gas or plasma, such as LED,
   OLED, or PLED.
M. TCLP: Toxicity Characteristic Leaching Procedure.
N. UV: Ultra Violet.
1.3 ACTION SUBMITTALS

A. Product Data: Submitted for review as a complete package, in form and quantities specified in Division 01, for the products specified herein, and in the Luminaire Schedule. Not less than the following product data shall be submitted:

1. A product data sheet, literature, drawing, etc., for each luminaire specified.
   a. The product data sheets shall be specific to the particular luminaire, light source, ballast, driver, and accessories specified, and shall be so annotated.
   b. The luminaires standard features and conformance with the specified options, features, performance criteria, etc.
   c. The manufacturer’s standard luminaire description, drawing, photo and fabrication specifications indicating conformance with the Luminaire Schedule and this specification section.
   d. Luminaire dimensional data.
   e. Light Source Data:
      1) Delivered Lumen Output.
      2) Rated Lumen Maintenance.
      3) Efficacy (Lumens per Watt).
      4) CCT.
      5) CRI.
      6) Wattage.
      7) Voltage.
   f. Photometric performance data, specific to the luminaires specific light source, driver, controller, and accessories specified.
      1) Where specifically stated, photometric data shall be performed and certified by an independent testing service regularly engaged in the testing and certification of luminaire photometric performance.
      2) Where not specifically stated, the photometric performance data provided by the manufacturer will be acceptable.
   g. Lumen maintenance (L(p) @ X Hours), expressed as a percentage of remaining lumens after a documented period of time, tested and measured in compliance with IES documents LM-79 and LM-80.
   h. Efficacy Data: Provide light source efficacy (LM/W), and luminaire efficiency (LER) if available.
   i. Where remote equipment is specified, or applicable, provide manufacturer’s recommended maximum remote distance length, wire size, and other requirements, for proper installation and operation.
   j. Compliance with Local or State Code.

2. A separate power supply, or driver product data sheet, or manufacturer’s specific literature, for each luminaire requiring same.
   a. Each product data sheet shall provide not less than the following information:
      1) Light source compatibility - by type and quantity.
      2) Input voltage.
      3) Light source starting method.
      4) Total input power consumption, in watts, including light source wattage and ballast/driver losses.
      5) Line current data.
      6) Total harmonic distortion data.

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3. In addition to, or as part of, the product data sheet submittal, provide a statement, certifying that the ballasts, power supplies, and drivers, along with the automatic lighting control devices (occupancy sensors, daylight harvesting controls, etc.) being supplied are compatible equipment, and do not compromise the proper operation of, and/or the design criterion of, the supplied ballasts, power supplies, drivers, or automatic control devices.

4. A separate emergency lighting accessory product data sheet, for luminaires specified with same.

B. Shop Drawings:

1. Layout Drawings: For custom, non-standard, and continuous row/length luminaires, submit fabrication type shop drawings, in addition to the standard manufactures data sheet(s). Indicate plan, elevation, and section views, along with dimensions, weights, methods of field assembly, components, features, and accessories.
   a. For continuous row and continuous length (including wall-to-wall) luminaires, provide scaled drawings indicating luminaire lengths and lamping requirements for each separate, individual length and row. Indicate layouts and quantities of individual luminaire housings, corners, transition components, spacers, etc.

2. Wiring Diagrams: Provide ballast quantities and wiring to provide conformance with switching, life safety, and other control requirements.

3. Lighting products that are slight variations of standard products, and/or continuous row/length versions of standard products, shall bear labeling from a NRTL.

4. Custom fabricated lighting products shall be tested in accordance with the appropriate standard(s), and shall bear labeling from a NRTL.

C. Samples for Verification: Submit samples of designated interior luminaires noted in Luminaire Schedule. Each furnished sample shall include the following:

1. Light Source: As specified – Installed in sample luminaire.
2. Cord and Plug: Wired to luminaire junction box.
3. 120V
4. Delivered with the specified finish/color applied, or provided with a finish/color sample for evaluation.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For agencies providing photometric data for luminaires.

B. Lighting Photometric Performance Calculations:

1. Provide software generated scalable lighting photometry plots indicating numerical illuminance values in point-by-point form, where and as directed.

2. Input data, for the purposes of generating the photometry plots shall indicate the design heights of luminaires, design reflectances for the various wall, ceiling and floor surfaces, initial lumen rating of the light source used, and design light loss factors including ballast factor, lumen depreciation factor, dirt depreciation factor, and any other light loss factors.

3. Provide summary illuminance data including maximum, minimum, average, and maximum to minimum uniformity ratio across the entire confines of the particular room area, or space.

4. Identify the lighting calculation software used to produce the photometry plot, date of plot, input data specified above, company name and individual responsible for producing the calculation.
C. Field Quality Control Test Reports:
1. Indicate and interpret test reports for compliance with performance requirements.

D. Warranties: Provide special warranties as specified in this Section, otherwise refer to Division 01.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Submit for review, in form and quantities, as specified in Division 01.
1. Copies of each approved action and informational submittal processed as part of the Work.
2. Copies of product warrant statements.
3. Copies of product installation and maintenance materials furnished with the equipment.
4. Provide complete sets (quantity as defined in Division 01) of product data sheets, reflected ceiling plans, wiring diagrams for project specific applications of each luminaire type for each application throughout the project.
5. Include dates of installation and replacement parts order information. Include light source and ballast/driver re-ordering information, and re-lamping schedule for luminaires appropriate for group re-lamping (HID). Include basic maintenance requirements, including luminaire and component cleaning.
6. Provide copies of spare lamp, luminaire and ballast, and other accessories delivery receipts.

1.6 QUALITY ASSURANCE

A. Provide luminaires factory designed, built and tested per the following standards:
1. Recessed Luminaires – In compliance with NEMA LE 4, for ceiling system material, type, and design compatibility.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing and Calculations Guides.

C. Solid State Lighting/Luminaires:
1. Luminous flux, luminaire efficiency and chromaticity shall be tested, measured, and reported in accordance with the most current versions of IES documents LM-79 and LM-80.
2. Chromaticity ranges for "white light" products, with various correlated color temperatures, shall be provided in accordance with ANSI/NEMA-C78.377.
3. Drivers and power supplies shall be provided in accordance with the requirements of ANSI/NEMA-C82.SSL.1 and their maximum allowable harmonic emission limits shall be in accordance with ANSI/NEMA-C82.77.
4. Shall be provided with a U.S. Department of Energy (DOE) "Lighting Facts" label indicating their specific performance characteristics, tested and reported in accordance with the requirements of the most current version of IES LM-79.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Except as otherwise specified herein, provide installation in accordance with the requirements of NECA/IESNA 500 – Standard for Installing Indoor Lighting Systems (ANSI).
F. Hazardous (Classified) Location Luminaires: Provide luminaires designed, fabricated, and tested in compliance with:
   1. UL 844 – Luminaires for Use in Hazardous (Classified) Locations.
   2. Factory Mutual Global (FMG) certification.
   3. NEC Chapter 5, for specific hazard class, division, and location requirements.


H. Provide in compliance with NFPA 70.

1.7 MOCKUPS
   A. In addition to those areas and requirements identified in Division 01, provide complete working mock-ups (including light source, ballasts, drivers, electrical connections, etc.) of the following luminaires and areas prior to final fabrication.
      1. Luminaire Types:
      2. Areas:
   B. Obtain Architect/Engineer approval of luminaires for mockups before starting installations.
   C. Install mock-up of luminaires in a manner closely conforming to that in which it will be permanently installed.
   D. Be present on site during Architect/Engineer review.
   E. Modify mock-up in accordance with mock-up discussions.
   F. Provide communications methods during mock-up, i.e. 2-way radio.
   G. Provide all equipment required for mock-up and review of mock-up, i.e. ladders, lifts, lamps, temporary power, etc.
   H. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
   I. Remove mockups when directed. Luminaires may be reinstalled in the work with approval of Architect/Engineer.
   J. Approved luminaires in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 COORDINATION
   A. Coordinate layout and installation of luminaires and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.
   B. Coordinate installation of luminaires to prevent the possibility of damage.

1.9 DELIVERY, STORAGE, AND HANDLING
   A. Provide for the coordination of luminaire procurement, delivery, expediting, ceiling material/luminaire compatibility, etc.
   B. Deliver luminaires in factory fabricated containers or wrappings which properly protect luminaires from damage. When possible, arrange for manufacturer to take back packaging materials to be recycled or reused.
C. Interior lighting equipment shall not be delivered to the job site, or installed, until the following atmospheric conditions can be maintained at the delivery point or installation location:

1. Ambient Temperature: 50 to 140 degrees F (10 to 40 degrees C).
2. Relative Humidity: 90 percent max., non-condensing.

D. Store luminaires and accessories in a secure, dry, heated location, protected from construction dust, dirt and debris, in their factory shipped cartons, pallets, packaging, etc., until ready for installation.

E. Handle luminaires carefully to prevent damage, breakage, or scoring of finishes.

1.10 SEQUENCING AND SCHEDULING

A. Coordinate with other work including; ceiling types, materials and construction, wires/cables, electrical boxes and fittings, and raceways, to properly interface installation of luminaires with other work.

B. Sequence luminaire installation with other work to minimize possibility of damage and soiling during remainder of construction.

C. Schedule the installation of luminaires and light sources, to allow for the specified lamp "burn-in" period.

1.11 CONTROLS PROGRAMMING, SETUP AND COMMISSIONING

A. Provide on-site construction personnel for the purpose of aiding outside vendors, factory technicians, and other duly authorized representatives of lighting equipment manufacturers, during their required controls programming, setup and commissioning of systems and equipment.

B. Provide not less than <insert number> total on-site hours (to include night-time on-site hours), and not less than <insert number> on-site visits, for this activity.

C. Provide for the services of a duly authorized, factory representative of the lighting control manufacturer/supplier for not less than <insert number> on-site hours, and not less than <insert number> on-site visits, to perform the tasks described in PART 3.

1.12 WARRANTY

A. Warranties specified in this Article shall be provided and shall run concurrent with other warranties required of the Contractor under the requirements of the Contract Documents. Warranty requirements being at time of Substantial Completion of project.

B. Warranty for LED Products: Written warranty, executed by manufacturer agreeing to replace luminaires and drivers, including labor, that fail in operation, fabrication, materials, or workmanship within five (5) years of installation.

C. Warranty for Luminaire Finishes: Written warranty, executed by manufacturer agreeing to replace luminaires, including labor, exhibiting a failure of finish as specified herein, within five (5) years of installation.

1. Protection from Corrosion: Warranty against perforation or erosion of finish.
2. Color Retention: Warranty against fading, staining, and chalking.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Luminaire Manufacturers: Subject to compliance with the requirements of this section and the design criteria specified in the Luminaire Schedule, provide products by the manufacturers listed in the Luminaire Schedule.

B. Reference to specific luminaire manufacturers and their respective model or series numbers, are included in the Luminaire Schedule to provide a guide as to the level of quality, performance, and overall physical appearance of the specified product, which shall be met, in accordance with the Luminaire Schedule’s design criteria, and as written herein.

C. Listed luminaire manufacturers and their series or model numbers shall not imply unconditional specification approval. The listed manufacturers and their respective products have been included as acceptable manufacturers of products which shall comply with the Luminaire Schedule design criteria, luminaire descriptions, and these specifications. Modification to a given manufacturer’s standard product may be required to make the model or series numbers listed comply with the Luminaire Schedule design criteria, and these Specifications.

   1. The preceding paragraph shall in no way suggest or indicate that a manufacturer’s UL/ETL listing be voided or otherwise compromised, in order to comply with the specified luminaire design criteria, descriptions or these Specifications.

D. Luminaire Products and Accessory Manufacturers: Subject to compliance with the requirements of this section, provide products from the manufacturers included herein.

E. Manufacturers of products not specifically listed in the Luminaire Schedule, or submitting on the basis of “or equivalent”, shall provide the following for review prior to, or along with product submission.

   1. Documentation showing a minimum of three years' experience in the business of the design and manufacture of lighting equipment similar to the type and quality of products specified.

   2. Product data and photometry demonstrating conformance with these specifications and the specific data included in the Luminaire Schedule.

   3. Prototype and/or operating sample of the product for evaluation by the Architect/Engineer. Prototype and/or sample shall be sufficiently detailed and operational to allow for fair evaluation and to demonstrate compliance with the salient features specified. Product data and shop fabrication drawings are not acceptable means of providing prototype/sample requirement.

   4. Architect/Engineer shall be the sole judge of compliance and reserves the right to disapprove manufacturer’s products other than what has been previously specified.

2.2 LUMINAires AND ACCESSORIES

A. General Requirements:

   1. Provide luminaires complete with the required and specified features, options, accessories, etc. Luminaires shall be provided as complete assemblies, ready for installation, including light source, ballasts, drivers, transformers, reflectors, shielding media, wiring and all other components required for a complete installation.

   2. Luminaires provided shall be constructed, wired, and installed in compliance with appropriate NRTL standards and applicable codes.

      a. Provide luminaires that are listed or approved for use in their application and location.
b. All products provided shall be listed, labeled, or otherwise approved by a NRTL, and shall be provided with the appropriate listing ID label(s) permanently affixed to the luminaire, concealed from normal view.

3. Except as otherwise noted, luminaires and their related accessories, light sources, ballasts, drivers, etc., shall be new, unused, factory tested, and ready for field installation.

4. Refer to Luminaire Schedule for additional luminaire specifications, descriptions, features and functions, color and finish selections, etc.

5. Recessed luminaires provided for installation in ceiling spaces known, or presumed, to be installed in direct contact with combustible materials within the ceiling cavity, shall be IR tested, rated, and so labeled.

6. Recessed luminaires provided for installation in known, or presumed air tight ceiling spaces, shall be designed to restrict airflow to under two cubic feet per minute, from the controlled environmental space to the ceiling space (or plenum), and shall be listed and labeled "Air-Tight."

7. Recessed luminaires provided for installation in known, or presumed fire rated ceiling assemblies, shall be UL classified, listed, and so labeled for use in fire rated ceiling assemblies.

8. Recessed luminaires shall be factory furnished with integral thermal protection devices, designed to automatically interrupt AC power applied to the luminaire lampholder(s).

9. Luminaires provided for recessed installation in false ceiling materials shall be designed and built for full access to concealed electrical components from below the finished ceiling material. Luminaire designs that require destruction, or removal of installed ceiling system components to allow access to concealed electrical components, do not meet this specification.

10. In general, luminaires shall be fabricated from sheet metal, or extruded metal parts. Except as otherwise specifically specified, noted, or indicated, non-metallic parts shall not be used in luminaire construction.

11. Lampholders shall be factory supplied, by the respective luminaire manufacturers, and shall be provided according to the luminaires designated lamping requirements.

12. Luminaires shall be constructed for safe installation. Luminaires shall be provided free from burrs, sharp edges and corners, and fabrication/tooling marks.

13. Provide luminaires complete with ceiling trims, accessories, and similar materials, to coordinate with the actual ceiling construction materials scheduled to be installed.

14. Provide luminaires complete with their full complement of required installation hardware, T-bar hangers, wood joist hangers, "C" channel bar hangers, outlet box canopies, pendant suspension kits, etc. The Contractor shall bear the responsibility for ceiling/luminaire installation coordination and procurement.

B. Recessed Luminaires: Comply with NEMA LE 4 for luminaire/ceiling compatibility.

C. Solid State Lighting Luminaires: Comply with UL 8750 and previously stated standards.

1. Luminous flux, luminaire efficiency and chromaticity shall be tested, measured, and reported in accordance with the most current versions of IES documents LM-79 and LM-80.

2. Chromaticity ranges for "white light" products, with various CCTs, shall be provided in accordance with ANSI/NEMA-C78.377.

3. Drivers and power supplies shall be provided in accordance with the requirements of ANSI/NEMA-C82.SSL1 and their maximum allowable harmonic emission limits shall be in accordance with ANSI/NEMA-C82.77.

4. Shall be provided with a U.S. Department of Energy (DOE) "Lighting Facts" or other label indicating their specific performance characteristics, tested, and reported in accordance with the requirements of the most current version of IES LM-79.
D. Metal Parts: Free of burrs and sharp corners and edges.

E. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.

F. Factory-Applied Labels: Comply with UL 1598. Include recommended light source, ballasts and driver information. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when luminaires are in place.

1. Label shall provide the following information:
   a. "USE ONLY" and include specific light source type.
   b. CCT and CRI.
   c. Solid state lighting driver and dimming requirements.

2. Provide DOE "Lighting Facts" label on all solid state lighting products.

G. Doors, Frames, and Other Access Components:

1. Doors, lens frames, access compartments, latches, etc., shall be smooth operating; designed and fabricated to trap produced light within the luminaire housing proper. No visible light leaks.

2. Luminaires shall be designed, built, and tested to allow for light source replacement without having to remove or disassemble luminaire components.

3. Lenses, louvers, diffusers, door frames, access covers, etc., shall be held captive, and shall be designed to limit the potential for accidental droppage during lamp replacement, luminaire cleaning, maintenance, etc.

H. Luminaire Coatings and Finishes:

1. Luminaire surfaces, components, trims, housings, etc., shall be factory pre-treated, rust proofed, primed, and otherwise prepared, to inhibit rust and corrosion. Exposed luminaire surfaces shall be factory pre-treated, primed, and finish coated with a suitable rust and corrosion inhibiting product.

2. Luminaire reflective surface coatings shall provide not less than the following minimum reflectance values:
   a. White Paint 85 percent
   b. Specular Surfaces 83 percent
   c. Semi-Specular Surfaces 75 percent
   d. Laminated Silver Metalized Film 90 percent

3. Except as otherwise indicated, provide the luminaire manufacturer’s standard factory finish material(s). The finish material color shall be as specified or otherwise indicated.

4. Where specifically specified, or otherwise indicated, custom finishes or color selections shall require written approval from the Architect prior to application. A sample of the custom finish or color shall be submitted, to the Architect, for approval.

5. Where a specific finish material, finish, or color, is specified, or otherwise indicated, the luminaire manufacturer shall factory apply the stated finish or color product to all visible luminaire surfaces, except those surfaces affecting luminaire performance. Except as otherwise indicated, luminaire finishes shall not be field applied.

6. Cast and extruded luminaire components and housings, specified with a natural or clear finish shall be factory coated with a baked-on, clear, methacrylate lacquer, transparent epoxy, or other suitable clear protective coating.

I. Reflectors, Cones, and Baffles:

1. Shall be fabricated free from spinning lines, ripples, and other surface imperfections.
2. Shall be designed for invisible and secure attachment and installation to luminaire housing. Shall be free from visible or exposed hardware.
3. Shall be designed and fabricated to prevent light leakage from the luminaire itself, and from the surrounding attachment materials and surfaces.
4. Shall be provided in the finish, color, material, and optical design properties specified in the Luminaire Schedule.

2.3 LENSES, DIFFUSERS, LOUVERS, AND LAMP SHIELDING MEDIA

A. General - Lenses and Diffusers:

1. Lenses shall be specifically designed, fabricated, and tested for the purpose of providing optically correct, measurable, and predictable light distribution results. Lenses shall facilitate light refraction, distribution, lamp shielding and glare control for artificial light source luminaires.
2. Except as otherwise noted, shall be fabricated from 100 percent clear, UV stabilized, virgin acrylic, material, specifically designed and tested for use with artificial illuminating light sources, and shall be non-yellowing as a result of aging, exposure to heat, and UV radiation.
3. Lens Thickness: Except as otherwise indicated, shall be fabricated and factory tooled to not less than 0.125 inch overall thickness.
4. Shall be designed, fabricated, and tested to maintain a maximum smoke development rating of 450 as required by ASTM-E84, and a maximum burning rate of 2-1/2 inches per minute as required by ASTM D635.
5. Deflection, measured at the center of a 24 inch x 48 inch lens or diffuser, from its edge, shall be not greater than 3/32 inch (0.094) below luminaire door/trim assembly. Negative cambers, molded into the lens or diffuser material, designed to arch the material upward, shall be acceptable.

B. Pattern 12 Lens – Shall be:

1. Not less than .125 inch overall panel thickness.
2. Not greater than .080 inch prism penetration depth.
3. (Inverted) Conical prisms, 3/16 inch square at penetration depth, straight flat-sided prism shape (concave sided, radiused prisms do not meet this specification), configured on a 45 degree axis layout, across the entire panel.

C. Pattern 19 Lens – Shall be:

1. Not less than .156 inches overall panel thickness.
2. Not greater than .080 inch prism penetration depth.
3. Bold (inverted) conical prisms, 3/16 inch square at penetration depth, straight flat-sided prism shape (concave sided, radiused prisms do not meet this specification), configured on a parallel/perpendicular 90 degree axis layout, across the entire panel.

D. Pattern 12 EMI Lens – Shall be similar to Pattern 12 lens specified: Provided with an additional Electro-Magnetic Interference (EMI) suppressing grid, consisting of an electrically conductive metallic grid, applied to the lamp side of the lens material.

1. Provided with a bonding conductor to bond the EMI suppressing metallic grid to the luminaire housing.
2. Designed, fabricated, and tested within the limits of MIL. STD – 461(F).
3. Acceptable Manufacturers: By luminaire manufacturer.
E. Pattern 19 EMI Lens – Shall be similar to Pattern 19 lens specified:
   1. Provided with an additional Electro-Magnetic Interference suppressing grid, consisting of an electrically conductive metallic grid, applied to the lamp side of the lens material.
   2. Provided with a bonding conductor to bond the EMI suppressing metallic grid to the luminaire housing.
   3. Designed, fabricated, and tested within the limits of MIL. STD – 461(F).

F. ASYM Lens – Shall be:
   1. Clear, virgin acrylic material, not less than .156 inch thickness, with both asymmetric and symmetric "V" shaped linear prisms formed into the panel.
   2. Where so specified, shall provide an additional Electro-Magnetic Interference (EMI) suppressing grid, consisting of an electrically conductive metallic grid, applied to the lamp side of the lens material.
   3. Provided with a bonding conductor to bond the metallic EMI suppressing grid to the luminaire housing.

G. Overlay Panel – Shall be:
   1. Milk white, translucent acrylic material, nom. 0.040 inch thick, with a matte finish on the surface away from the lamp(s).

H. Glass Lenses and Diffusers: Annealed crystal glass unless noted otherwise.
   1. Globes and Guards – Shall be provided for protection of luminaires and their interior components.
      a. Globes shall be fabricated of shatterproof, heat and impact resistant materials, formed to luminaire contours, for integral and secure installation.
      b. Glass globes, diffusers and lenses shall be fabricated from annealed crystal glass, or tempered glass, unless otherwise noted.
      c. Cast guards shall be of copper free die-cast aluminum construction, formed to luminaire contours, for integral and secure installation.
      d. Wire guards shall be formed wire, min. 16 AWG, spot welded at crossing intersections, and factory painted to match luminaire color, or non-painted stainless steel, where so specified.
      e. Acceptable Manufacturers:
         1) By luminaire manufacturer.

2.4 ELECTRO-MAGNETIC AND RADIO FREQUENCY INTERFERENCE
A. Where specified, noted, or otherwise indicated, provide electro-magnetic interference and radio frequency interference (RFI) (EMI) filters, factory installed in series with each luminaire ballast (one filter per ballast), to limit or suppress radiated or conducted EMI and RFI.
B. Filters shall be designed, built, and tested to mitigate both EMI and RFI, in compliance with the requirements of Mil. STD – 461(F), and Federal Specification 47 CFR 18, Chapter 1, Subpart C.
C. Acceptable Manufacturers:
   1. By luminaire manufacturer.
ILLUMINATED "EXIT" LUMINAIRES

A. Shall be factory designed, built, and tested in accordance with UL 924, and with ordinances and codes applicable in the project locale.

B. Except as otherwise indicated, shall be solid, full face(s) fabricated from the specified material, with "EXIT" letters and directional chevrons stencil cut out of face material, and red acrylic sheet installed behind stencil cut.
   1. Where indicated to be edge-lit style, sign face(s) shall be fabricated from clear sheet acrylic material, with "EXIT" letters and directional chevrons engraved into face, filled in solid red color.
      a. Where indicated to be double face, provide a specular, two-sided, silver mirror finish Mylar sheet between opposing sign faces.

C. Shall, under normal operating conditions, consume 5 watts of AC power, or less, per face.

D. Unless indicated otherwise, shall be provided for AC operation, with multiple LEDs as the light source for internal illumination.

E. Where indicated, shall be of the self-contained, AC/DC, integral battery standby operating type, with multiple LEDs as the light source for internal illumination in both modes of operation.
   2. Charger: Fully automatic, solid-state, constant current type, with integral, sealed transfer relay.
   3. Low Battery Disconnect: Provide a device and/or related circuitry that shall automatically disconnect the battery and protect it from deep/over discharge.
   4. Operation: Under "normal" conditions the luminaire is illuminated via its integral lamps, supplied from the AC voltage source, and the standby battery is in the float charge mode. Upon loss of AC voltage, or AC voltage falls below 80 percent of nominal system voltage, the integral transfer relay shall sense to the abnormal condition and automatically disconnect the luminaire lamps from the "normal" AC voltage source and transfer their operation to the standby battery voltage DC voltage source. Upon return of the "normal" AC voltage source, the integral transfer relay shall sense the return of "normal" AC voltage, and retransfer operation of the lamps back to the "normal" AC voltage source. The integral battery shall be returned to the charge mode.
      a. Integral battery shall provide not less than 90 minutes of rated illumination time.
   5. Test Push Button: Push-to-test type, integral to unit housing. Simulates loss of "normal" AC voltage, and initiates DC battery standby operation.
   6. AC Pilot Light: LED "ON" indicates normal AC power is connected. Normal pilot lamp intensity indicates unit is operating in the float charge mode. Bright pilot lamp intensity indicates unit is operating in the full charge mode.

F. Integral Self-Test: Except as otherwise noted, illuminated "EXIT" sign luminaires shall be provided with integral self-test feature and diagnostics.
   1. Provide integral solid-state electronic circuitry and related components that shall:
      a. Automatically initiate a one minute lamp burn, battery discharge, and internal diagnostic test at least once every 30 days.
      b. Automatically initiate a 30 minute lamp burn, battery discharge, and internal diagnostic test once every 6 months.
      c. Comply with the periodic testing requirement of the NEC Article 700, NFPA 110, and the local authority having jurisdiction.
d. Provide positive, visual indications of unit malfunctions, during the self-testing routines, and during "normal" operating conditions.

e. Constantly monitor the proper operation of the luminaire charger and lamp operation.

2. In addition to the pre-programmed, self-testing, diagnostic routines, luminaires provided shall provide for manual testing, providing user controls to initiate luminaire testing.

3. Equipment malfunctions diagnosed, shall be retained in permanent memory within the solid-state electronics, until corrected and reset.

G. Standard Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery powered illuminated "EXIT" signage agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

H. Acceptable Manufacturers:

1. Refer to Luminaire Schedule.

2.6 LIGHT SOURCES

A. Acceptable Manufacturers:

1. Basis of Design – Products manufactured by the Philips Lighting Company, [GE Lighting,] [Osram/Sylvania,] hereinafter referred to as Philips, [GE] [Sylvania] have been specified as the Basis of Design. Products from the following listed manufacturers may be considered equivalent, providing their product specifications meet or exceed the Basis of Design specification:

   a. Solid State:
   b. Cree.
   c. Citizen.
   d. LG Innotek.
   e. Nichia.
   f. Osram Opto Semiconductor.
   g. Philips Lumileds Lighting.
   h. Samsung LED.
   i. Seoul Semiconductor.
   j. Bridgelux.
   k. Or as supplied by the luminaire manufacturer, in compliance with these Specifications.

2.7 LED LIGHTING PRODUCTS

A. Luminaires:

1. Refer to Luminaire Schedule for specified parameters such as correlated color temperature (CCT) value(s), lumen output, efficiency, etc.

2. Products shall be fabricated to be Reduction of Hazardous Substances (RoHS)-compliant.

3. Must maintain their warranted life while operating within the manufacturers’ specified environmental parameters.

4. The lumen maintenance specification of any assembled LED based chip, array, module, driver, and luminaire combination shall be a minimum of L70, at 50,000 hours, as tested and measured in compliance with IES documents LM-79 and LM-80.

5. Except as otherwise stated in the Luminaire Schedule, the light source shall provide a minimum CRI of 80.
6. Acceptable Manufacturers:
   a. Refer to the Luminaire Schedule.

B. Drivers: Listed and so labeled per UL 8750 and UL 1310, and shall meet or exceed the following general specification criteria:
   1. Designed and tested to be compatible with the luminaire light source operating current, voltage, and output power requirements.
   2. Inaudible above 27 dBA ambient sound level.
   3. Designed, fabricated, and tested to operate at an input voltage of 120 – 277VAC, ±10 percent, at 60 Hz, with no perceptible change in light source output.
   4. Contribute less than 20 percent total harmonic distortion, operating at full rated load, and shall not exceed the maximum allowable THD requirements allowed per standard ANSI C82.11.
   5. Provided with integral short circuit, open circuit, and overload protection.
   6. Have an operating power factor ≥ 0.9.
   8. Housed in a UL compliant and listed enclosure, suitable for remote installation where required, and listed for installation within spaces used for environmental air (plenum), as defined in NFPA-70 – the National Electrical Code.
   9. Acceptable Manufacturers:
      a. Cree.
      b. EldoLED.
      c. Philips/Advance.
      d. Osram.
      e. Thomas Research Products.
      f. Or as supplied by the luminaire manufacturer, in compliance with these Specifications.

C. Dimmable Drivers - In addition to the general specification criteria specified above:
   1. Have an operating power factor of ≥ 0.9 at full load, and not less than 0.8 at dimmed level.
   2. Provide smooth, flicker-free, dimmable light output from 100 percent to less than 1 percent.
   3. 0-10VDC "sinking" type dimming control protocol per enforced version of IEC Standard 60929, unless otherwise noted or required.
   4. Acceptable Manufacturers:
      a. Cree.
      b. EldoLED.
      c. Philips/Advance.
      d. Thomas Research Products.
      e. Or as supplied by the luminaire manufacturer, in compliance with these Specifications.

2.8 EMERGENCY LIGHTING PRODUCTS

A. Self-Contained, Emergency Lighting Battery Units (EBU):
   1. Description: Shall be self-contained, emergency lighting units complying with UL 924, and provided with the following features and functions:
      a. Battery: Sealed, maintenance free, nickel-cadmium type, factory installed integral to the unit housing.
      b. Charger: Fully automatic, solid-state type, with sealed transfer relay.
c. Operation: Under "normal" operating conditions, the units' light source is not illuminated, and the integral battery is in charge mode. Upon loss of AC voltage, or AC voltage falling below 80 percent of nominal system voltage, the integral transfer relay shall sense the abnormal condition, and automatically apply integral battery standby/emergency power to the units' light source; illuminating them for not less than 90 minutes, or until "normal" AC power is restored, if outage duration is less than 90 minutes. Upon return of "normal" AC power, the integral transfer relay shall sense the return of "normal" AC voltage, and shall automatically disconnect battery power from the units' light source, and the battery shall be returned to the charge mode.

1) Integral battery shall provide not less than 90 minutes of rated illumination time.

d. Test Push Button: Shall be push-to-test, integral to the luminaire housing. Shall simulate loss of "normal" AC power, and initiate DC battery standby operation.

2. Integral Self-Test: Except as noted, provide with integral self-test feature and diagnostics. Provide the following:

a. Luminaires shall be provided with integral solid-state electronic circuitry and related components that shall:

1) Automatically initiate a one minute light source burn, battery discharge, and internal diagnostic test once every 30 days.
2) Automatically initiate a 30 minute light source burn, battery discharge, and internal diagnostic test once every 6 months.
3) Comply with the periodic testing requirement of the NEC Article 700, NFPA 110, and the local authority having jurisdiction.
4) Provide positive, visual indications of unit malfunctions, during the self-testing routines, and during "normal" operating conditions.
5) Constantly monitor the proper operation of the luminaire charger and light source operation.

b. In addition to the pre-programmed, self-testing, diagnostic routines, luminaires provided shall provide for manual testing, providing user controls to initiate luminaire testing.

c. Equipment malfunctions diagnosed, shall be retained in permanent memory within the solid-state electronics, until corrected and reset.

3. Provide a retransfer to "normal" time delay feature that shall continue to operate the luminaire light source for not less than 15 minutes, after "normal" power has returned.

4. Shall be designed, tested, and fabricated to be in compliance with RoHS requirements.

5. Protection: Heavy gauge, chrome-plated, or painted steel wrap around cage to protect entire unit.

6. Provide metal shelf style support for units that are provided with cord and plug, and for units too large or too heavy for direct installation over outlet box.

7. Warranty: Contractor shall provide a full, no cost, replacement warranty during their contracted guarantee period. After the contractors guarantee period, the equipment manufacturer shall provide a pro-rated reduced cost warranty for not less than 9 years.

8. Referenced Products:

a. Refer to Luminaire Schedule.

B. EMERG/LED Emergency Lighting Devices for LED Luminaires:
1. Where indicated, scheduled, or shown, provide single, self-contained emergency lighting inverters designed specifically for installation immediately adjacent to, or remote from, a given LED luminaire.

2. Shall be provided with the following performance specifications, features, and requirements:
   a. Integral Battery - Maintenance free, nickel cadmium type.
   b. Charger – Integral to housing, solid-state type, designed, built, and tested to recharge a fully discharged battery in not more than 24 hours.
   c. Inverter - Integral to housing, sinusoidal 60 Hz. rectifier/inverter.
   d. AC voltage sensing circuitry and transfer relay.
   e. Metal "F" can enclosure designed for remote installation from luminaire.
   f. Test switch and pilot/charger indicator light.

3. Shall be UL listed for factory or field retrofit, in accordance with Underwriter's Laboratories Standard 924 – Emergency Lighting and Power Equipment.

4. Shall be designed, built, and tested for dual input voltage compatibility – 120/277VAC, 60 Hz.

5. Shall be designed, tested, and fabricated to be in compliance with RoHS requirements.

6. Devices designated, or otherwise indicated, to be installed remote from a given luminaire housing, shall be provided with a listed and approved remote mounting enclosure.

7. Operation: Those luminaires specified with emergency lighting devices shall:
   a. Under "normal" operating conditions - the device shall provide AC input to the given luminaires' integral or remotely installed driver, and the battery shall be charged.
   b. Under a "power fail" mode – the device integral voltage sensing circuit shall sense loss of "normal" AC power, and transfer operation of the device to integral battery power, maintaining the AC input to the luminaire, allowing the luminaire to operate at the device's rated lumen output, for not less than 90 minutes, or until "normal" AC power is restored, if outage duration is less than 90 minutes.
   c. Upon restoration of "normal" AC power, the device integral voltage sensing circuit shall sense the return of "normal" AC power, and the device integral transfer relay shall automatically re-transfer operation of the device from integral battery, to "normal" AC power input to the luminaire driver. The device shall automatically revert back to battery charge mode.
   d. The device shall allow the connected luminaire to be switched (ON/OFF) or dimmed, under "normal" operating conditions, and regardless of switch position or dimmed light level, shall, upon loss of "normal" AC voltage, provide illumination to the devices rated lumen output.
   e. Provide not less than 90 minutes of rated illumination time, from the integral battery.

8. Where shown, indicated, or otherwise noted, provide low temperature emergency lighting devices as follows:
   a. Designed, tested, and fabricated to operate the designated luminaire(s) in an ambient temperature range of -20 degrees C to +60 degrees C (-4 degrees F to +140 degrees F).

9. Rated Load Output: Not less than 20W total (including luminaire ballast/driver losses) at 120/277VAC, 60 Hz.

10. Provide devices complete with remote test station:
a. Remote test station shall be a single pole, momentary contact, push button switch, and a red, charge indicator LED light, factory installed on a single gang, stainless steel coverplate, engraved and filled to read "PUSH TO TEST", and "CHARGING INDICATOR".

b. Contractor shall provide field wiring between the remote test switch station locations and the emergency lighting device locations.

11. Warranty: Five (5) year full product replacement (not pro-rated) warranty against defects in manufacture or installation.

12. Referenced Product:
   b. Or equivalent.

2.9 LIGHTING TRANSFORMERS

A. Luminaire installed 120 Volt Secondary Transformers:
   1. Provide separate primary fusing and disconnect for each transformer.
   2. Provide NFPA 70 Class 2 transformers that are energy-limited to 100VA maximum.

B. Low Voltage Power Distribution Center: Provide product consisting of the following.
   1. Separate compartments for primary line voltage, transformer, and secondary circuit protection.
   2. UL listed distribution center suitable for surface, recessed, and suspended mounting in walls and ceilings as indicated.
   3. Inherently protected system requiring zero clearance to combustible materials.
   4. Toroidal-wound low voltage transformer with integral thermal protection.
   5. 4-primary taps on transformer to vary the secondary output from nominal to above nominal voltage.
   7. Primary protection circuit breaker.
   8. Minimum 0.1-inch thick aluminum cover, white finish.
   9. Unit-mounted user disconnect switch.
   10. Security auto fuse extension (SAFE) for use with live conductor lighting systems.
   11. Internal primary choke for use with dimmers.
   12. Acceptable Manufacturers:
      a. Q-Tran, Inc.
      b. Semper Fi.

2.10 LUMINAIRE SUPPORT COMPONENTS

A. Comply with Division 26 Section "Hangers and Supports" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as luminaire.

E. Luminaire Support Chains: Not less than #12 chain link style, provided with "S" hooks for linking chain lengths together, and fastening devices to allow for independent attachment and anchoring to building structure.

F. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

G. Hook Hangers: Integrated assembly matched to luminaire and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to the Luminaire Schedule for additional installation information.

B. Refer to the Contract Drawings for quantities and intended locations of luminaires.

C. Provide for the coordination of ceiling material/luminaire construction, and installation coordination with the work of this Division, and the work of other Divisions.

D. Provide for the component coordination of light sources, ballast, drivers and control system requirements with the respective luminaire manufacturers and suppliers, prior to procurement, to provide the specified performance.

E. Provide for the installation coordination of the various interior lighting system components with field construction. Verify that the various luminaires provided are compatible with and coordinate with the various ceiling types, materials, and their construction restraints.

1. Specific luminaire ceiling system compatibility and installation components are purposely not identified or specified. Coordination of this compatibility and installation shall be the responsibility of, and provided, under Division 26, prior to the procurement of lighting equipment.

F. Refer to the Contract Documents and coordinate the installation of interior lighting equipment with respect to luminaire quantities, luminaire construction with respect to their installation into a particular surface or material, luminaire quantities, etc.

G. Be responsible for continuous row quantities and lengths. Provide field dimensions to the luminaire manufacturer, for luminaires specified and designed for continuous, wall-to-wall installation.

3.2 INSTALLATION – LUMINAIRES

A. Install luminaires and their related accessories at locations and heights, as shown on Drawings, in accordance with the respective luminaire manufacturer's instructions, and the applicable requirements of the NEC, NECAs "Standard of Installation," NEMA standards, and with recognized industry practices.

B. Provide luminaires and their associated outlet boxes, with hangers, supports, fasteners, etc., to properly support their weight. Refer to Division 26 Section "Hangers and Supports." Submit design of hangers, method of fastening, other than indicated or specified herein, for review by the Architect.

C. Except for luminaires designed to be installed and secured directly to their associated outlet box only, luminaires shall be independently supported and fastened to/from the building structure or ceiling systems and not to the work of any other construction trade.
D. Provide luminaires of the same type indicated, in any given room or space, except as otherwise indicated.

E. Provide, for luminaires not factory pre-wired to integral outlet box; an outlet box - installed not less than 12 inches from the luminaire wiring terminals, with not more than 72 inches of tap conductor/cable length, installed in accordance with NEC Article 410, between the outlet box and the luminaire wiring terminals.

F. Luminaire Arrangements:
   1. General:
      a. Install plumb, square, and true to building construction. Where indicated by dimension, or shown on the Drawings, maintain indicated arrangement.
   2. Flush/Recessed:
      a. Roughed in a concealed wiring method, with concealed outlet box(s), backbox(s), etc., installed flush to the face of the respective wall, floor, or ceiling material.
   3. Surface:
      a. Roughed in a concealed wiring method, with concealed outlet box(s), installed flush to the surface of the respective wall, floor, or ceiling material.
   4. Exposed:
      a. Roughed utilizing an exposed wiring method, to either exposed electrical outlet box(s), or roughed directly into the exposed luminaire.
      b. Installed directly over said outlet box(s), or wired directly to the exposed wiring method, and shall be securely fastened to building surfaces or appurtenances, plumb, square, and true to building construction.
   5. Orientation:
      a. Install luminaires such that, in any given space, all luminaires and light sources align in the same direction. Verify orientation with Architect.
   6. Continuous Length Installations:
      a. Provide maximum 4-foot length enclosures in continuous end-to-end linear luminaire installations.
      b. Where individual length luminaires are indicated, noted, or otherwise directed to be installed in end-to-end, continuous lengths; provide additional supports, fastening means, wiring method(s), hardware provisions, etc., to facilitate the installation without gaps or openings between adjacent luminaires.
      c. Luminaries shall be designed, fabricated, and listed for feed-thru wiring.
      1) Luminaires not designed, fabricated, or listed for feed-thru wiring shall be installed in a concealed wiring method, connecting adjacent luminaires.

G. Flush/Recessed Luminaire Installation:
   1. Verify construction of wall, floor, or ceiling, and its finished surface material, prior to luminaire installation.
   2. Provide luminaires complete with factory supplied plaster flanges, frames, etc., to facilitate the installation of recessed luminaires in wet plaster and drywall type ceilings.
   3. Provide, in concert with the luminaire manufacturers, the required installation hardware, mounting clips, rails, hangers, and related luminaire accessories, to facilitate flush luminaire installations.
4. Provide gaskets, flanges, etc., to prevent "light leaks" around luminaires.
5. Provide field or factory supplied T-bar suspension bars, rails, etc., and hold down clips or devices, designed for compliance with NEC Article 410.
6. Provide not less than two suspension attachments for each luminaire installed.
   a. Each supporting means shall be fastened and secured to the building structure or ceiling system and shall have a breaking strength of not less than the weight of the luminaire, plus a safety factor of 3.
   b. The suspension means shall be attached to the luminaires at their designated factory established attachment points.
   c. Ensure fixture support installation is in compliance with the ceiling system manufacturer’s requirements.

H. Stem/Pendant Style Luminaire Installation:
   1. Provide hang-straight, swivel style canopies for stem/pendant hung luminaires, such that the luminaires hang plumb and level (unless otherwise indicated). Security attach outlet box feed points and intermediate supports to the building structure, to support not less than twice the weight of the suspended luminaire.
   2. Outlet boxes and electrical feed points shall be installed above the luminaire(s) with branch circuit wiring/cord drop(s) extended down to luminaire housing concealed inside rigid raceway pendants; or exposed, attached to, and following length of cable suspension points.
   3. Coordinate feed point and intermediate support canopy locations with the Architect, prior to roughing. In general, canopy locations shall be either centered at a grid intersection, or centered within a ceiling tile. Verify exact locations with Architect prior to roughing.
   4. Install canopies, and their associated electric work, provided for continuous row luminaire applications in straight, rows, with no discernible deflections.
   5. Provide stems and pendants, by the luminaire manufacturer, in quantities as recommended by the luminaire manufacturer, to provide a straight, level, installation, with no discernible luminaire deflection.
   6. Provide individual stem/pendant mounted luminaires with not less than two stems or pendants per luminaire.

I. Surface Installation:
   1. Install tight to surface without distorting surface or luminaire. Supports shall be provided on 4 foot centers maximum, with a minimum of two hangers per individual four foot luminaire and three hangers per individual eight foot luminaires.
   2. Space luminaires in continuous rows to correspond to ceiling joint intersections. Continuous row luminaires may be fed from a single outlet where luminaires are listed as approved wireways and suitable wiring is used.
   3. Provide hangers for each luminaire, each rated to support not less than four times the luminaire weight.
   4. Provide offset or trapeze hangers where required. Hangers shall be securely attached to the building structure and independently supported from ceiling system or other building appurtenances.
   5. Provide factory supplied surface luminaire collar where outlet box serving luminaire cannot be (or is not) roughed flush to face of installation surface.
      a. If collar assembly is not available from luminaire manufacturer, Contractor shall fabricate same, or shall have collar fabricated by others.
      b. Surface collar shall match luminaire’s attachment points and raceway entries into and out of collar/outlet box.
      c. Limit collar depth to depth of outlet box or raceway size servicing luminaire.
6. Surface Wall Installation:
   a. Unless otherwise specifically noted, install luminaires true, square and plumb to building construction.
   b. Except for luminaires specifically designed, fabricated, and instructed, for canopy style installation directly over outlet box, provide additional supporting means.

J. Relocated Luminaires:
   1. Refer to Division 26 Section "Selective Removals, Relocations, and Rearrangements," for additional relocated luminaire requirements.
   2. Remove luminaires from existing locations and store as for new luminaires. Reinstall as shown on Drawings. Before reinstalling, luminaires shall be cleaned, provided with new light sources, ballasts, etc., and repaired. The following shall be performed:
      a. Replace ballast.
      b. Replace broken, damaged, worn or faulty lamp sockets.
      c. Provide new luminaire wire.
      d. Replace lenses.
      e. Provide new light sources.
      f. Completely damp clean lens and interior.
      g. Mount as required for new luminaires.

K. Fasten luminaires securely to supports provided.

L. Emergency Lighting Products Installation:
   1. Unless noted, shown, or otherwise indicated, refer to manufacturers published instructions for field installation directions.
   2. Luminaires provided for "EXIT" and other directional signage shall:
      a. Be connected unswitched to their designated branch circuit wiring.
      b. Be installed at locations indicated, at heights and elevations providing maximum visibility and readability, in accordance with Section 7.10 of NFPA-101, Life Safety Code.
   3. Unless noted or shown otherwise, luminaires provided for emergency lighting purposes shall be connected unswitched to their designated emergency lighting branch circuit wiring.
      a. Provide an unswitched normal power branch circuit conductor for normal voltage sensing to emergency lighting devices that are controlled by other equipment and devices.
      b. Refer to Division 26 Section "Low Voltage Electrical Power Conductors and Cables (100-600 Volts)" for additional requirements.
   4. Provide wiring to Emergency Lighting Bypass Devices (ELBDs) and between the ELBDs and their connected luminaire(s) with a wiring method as allowed by NEC and as allowed/specified in other project manual specification sections.
   5. Unless noted or shown otherwise, EMERG/FL, EMERG/LED, and ELBD1s shall be factory installed within, or integral to luminaire housings as the preferred installation method. Installation of these products remote from a given luminaire’s housing may be provided, if:
      a. Authorized and permitted by the Architect.
      b. Installation is performed per equipment manufacturer’s direction.
      c. Allowed by the authority having jurisdiction.
      d. Installation complies with the equipment’s listing and labeling requirements.
      e. Installation within, or integral to, a given luminaire’s housing is not possible or practical.
6. Emergency Lighting Bypass Devices (ELBD's) shown, noted, or otherwise indicated to be installed remote from their associated emergency lighting luminaires, installed in concealed, readily accessible locations, allowing devices to be serviced, maintained, and tested.

7. Securely fasten emergency lighting battery units to intended surface. Provide suitable anchors and backing to secure unit to surface. Provide anchored metal shelves for the installation of emergency lighting battery units, too large and too heavy to install directly over outlet boxes.

8. Install remote test/pilot light component within direct viewing field of luminaires equipped with emergency lighting devices, and within the maximum distance limitation stated in the manufacturer’s installation instructions.
   a. Verify exact locations with Architect, prior to roughing.
   b. Unless otherwise specifically noted or indicated, remote test/pilot light devices shall be installed flush to wall or ceiling construction, utilizing concealed construction means and methods.
   c. Provide field wiring between remote test/pilot light device locations and the emergency lighting devices.

9. Emergency Lighting Asset Tags: Provide facility asset tags for emergency lighting in accordance with the Asset Tag Section.

M. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B, and the National Electrical Code.

N. Provide complete electrical connection(s) to luminaires furnished and installed under other Divisions, or furnished under other Divisions and installed under Division 26, such as:

1. Film Illuminators:
   a. Units designed for flush-to-wall recessed installation, with concealed backbox/housing, shall be direct connected utilizing a concealed wiring method.
   b. For Units designed for surface installation, with exposed backbox/housing, provide a duplex receptacle, under right hand corner of unit, as indicated on Drawings.

2. Pre-Fabricated Shower Modules:
   a. Provide concealed branch circuit and switch control wiring to luminaire factory installed within shower enclosure.

3. Under cabinet and under transaction counter luminaires:
   a. Connect through concealed branch circuit and remote switch control wiring, as shown on Drawings. Connect multiple units in common locations to common switch control. Coordinate number of luminaires per cabinet or counter length with other Divisions.

4. Exam lights and Surgical Lighting Luminaires:
   a. Verify exact locations of luminaires and remote control devices with architect and luminaire supplier prior to the roughing.
   b. Verify outlet box/backbox requirements with equipment supplier prior to roughing. Provide outlet boxes and backboxes as directed.
c. Provide concealed branch circuit and control wiring to luminaires and remote control devices.
d. Install per manufacturer’s instructions.

3.3 LIGHT SOURCES

A. Install in all luminaires. Products shall be new and unused.

B. If permanent lighting system is used for temporary construction lighting, light sources shall be replaced upon turn over to Owner.

C. Replace light sources that have failed in temporary luminaires provided for lighting during construction.

D. Replace light sources that have failed in permanently installed luminaires that have been allowed to be used for lighting during construction.

E. Replace light sources that have failed within their published warranty period, if so stated, or within their published average life span, during the Contractor’s warranty period.

F. Batch replace HID lamps whose color consistency (in the opinion of the Architect or Owner) varies from lamp to lamp. If such color in consistency exists, replace all lamps within a given room or space to the Architect’s or Owner’s satisfaction.

G. Provide, to the Owner, light sources replacement warranty information for their use in resolving replacement issues with the light sources manufacturers.

3.4 LED DRIVERS

A. Provide complete connection to LED type luminaires thru both integrally installed and remote electronic drivers.

B. Verify the dimming protocol required between the supplied step/continuous dim driver(s) and the supplied dimming control devices/equipment. The contractor shall bear the responsibility for providing compatible drivers and control devices/equipment.

C. Remote drivers are specifically not shown on the Drawings. Contractor shall install remote drivers in a readily accessible, dry, indoor, concealed location, in accordance with the manufacturer’s instructions.

D. Provide ventilated metal enclosures for remote drivers furnished as loose equipment. All wiring to/from remote drivers and their associated LED luminaires shall be installed in raceway.

E. Verify and comply with remote distance limitations specified by the luminaire/driver manufacturer.

3.5 LENSES, DIFFUSERS, LOUVERS, AND LAMP SHIELDING MEDIA

A. Install specified products for luminaires.

B. Clean lighting equipment and luminaires of dirt and construction debris upon completion of installation. Clean fingerprints, smudges, wrapping, etc., from lenses, baffles, louvers, reflectors, etc.

C. Protect installed luminaires from damage during remainder of construction activity. Replace lenses, baffles, louvers, reflectors, etc., damaged or broken prior to, during, or after installation.
3.6 ADJUSTMENTS AND RELOCATIONS

A. Provide for field directed adjustments to lighting equipment, luminaires, etc., and their previously installed roughing, as follows, under contract:
   1. It is intended that field directed adjustments be limited to relocation of lighting equipment, luminaires, etc., to directed locations within 10 feet of their presently installed location.
   2. Provide for not less than 24 hours of workman's time to disconnect, remove, relocate and re-connect lighting equipment, luminaires, etc., presently installed, to new location(s) directed.
   3. Provide for required tools, equipment, ladders, scaffolding, etc., to facilitate the directed adjustments.
   4. Provide for the electrical construction work, means and methods required to disconnect, remove, relocate and re-connect lighting equipment, luminaires, etc.

B. Provide, after the lighting installation is substantially complete, preliminary aiming of adjustable luminaires. Provide preliminary control settings for luminaires. Verify that luminaires are fully operational.
   1. After the lighting installation is complete, provide two (2) electricians, tools, and equipment, for not less than 16 hours total, to access and adjust luminaires with Architect and Lighting Designer after dark. Schedule through appropriate correspondence channels.

C. Occupancy Adjustments: When requested, within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide for not less than two visits to Project site, at other-than-normal occupancy hours, for this purpose. Some of this work may be required after dark.
   1. Adjust aimable luminaires in the presence of Architect and Lighting Designer.

3.7 BONDING

A. Provide bonding of all luminaires and their associated controls, to the equipment ground system. Tighten connections to comply with tightening torques specified in UL Standard 486A to provide a permanent and effective bonding path to ground.

3.8 DEMONSTRATION

A. Apply electrical energy to luminaires, upon completion of their installation, and after building circuitry has been energized to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

3.9 FIELD QUALITY CONTROL

A. Inspections and Tests:
   1. Perform inspection and test procedures as specified in Division 26 Section "Electrical Inspections and Testing", and the following additional requirements:
      a. Prepare test and inspection reports.

B. Standby/Emergency Lighting Luminaires:
   1. Interrupt the normal power source to demonstrate proper luminaire operation after units have been installed and building circuits have been energized under normal power source.
   2. Remove and replace malfunctioning units with new units and proceed with retesting.
   3. Give the Architect advance notice of dates and time for field tests.
Provide instruments as required to make positive observation of test results. Include the following in tests:

a. Duration of supply (verify minimum 90 minutes of illumination).
b. Low battery voltage shutdown (verify feature is operational to avoid deep discharge of batteries).
c. Normal transfer to battery source and retransfer to normal.
d. Low supply voltage transfer (verify Brownout feature to ensure illumination is provided via batteries during times of voltage sags).
e. Insulation Resistance Test: Perform as specified in Division 26 Section "Low Voltage Electrical Power Conductors and Cables," both before and after connection of luminaires and equipment.
f. Electrical Continuity Tests: Perform as specified in Division 26 Section "Low Voltage Electrical Power Conductors and Cables."

C. Prepare, and deliver to the Architect, at Substantial Completion, a written report of all conducted tests, inspections, observations, and verifications, indicating and interpreting results. If adjustments are made to the previously tested installation, retest to demonstrate compliance with the project requirements or indicated standards.

3.10 STARTUP SERVICE

A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner.

3.11 DISPOSAL OF REMOVED LIGHTING EQUIPMENT

A. Refer to Division 26 Section "Selective Removals, Relocations, and Rearrangements" for requirements.
<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturer</th>
<th>Model</th>
<th>USE ON CAMPUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot; Round Open Downlight</td>
<td>Cree Lighting</td>
<td>KR4 Series (Dimmable)</td>
<td>To match existing areas with KR4 fixture</td>
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<td>4&quot; Recessed Round Downlight</td>
<td>Current</td>
<td>LRXB R4-1X-9-CW-VQ-FRAME4R-BH3</td>
<td>General</td>
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<tr>
<td>6&quot; Recessed Round Downlight</td>
<td>Current</td>
<td>LRXB-R6-1X9CWVQ-FRAME6R-BH3</td>
<td>General</td>
</tr>
<tr>
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END OF SECTION 265100
SECTION 265600 – EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY
A. This Section provides specifications and design criteria for the following:
   1. Exterior luminaires and their associated lamps, ballasts and accessories.
   2. Photoelectric controls integral to luminaires.
   3. Poles, luminaire support structures and their associated accessories.

1.2 DEFINITIONS
A. CRI: Color-rendering index.
B. Luminaire: A complete lighting assembly or product consisting of not less than a light source(s) and related devices to position the light source(s), housing or enclosure, light source control and optics and light source power supply control device(s).
C. NRTL: Nationally recognized testing laboratory.
D. Pole: Luminaire support structure, including tower for large area illumination.
E. Solid State Lighting/Luminaires: Light sources and their associated luminaires that produce light (radiant energy) without the use of electrical filaments, excited gas or plasma, such as LED, OLED, or PLED.
F. Standard: Same definition as "Pole" above.
G. TGIC – Triglycidyl Isocyanurate polyester powder type paint finish.

1.3 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION
A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4.
B. Ice Load: Load of 3 lb/ft² (143.6 Pa), applied as stated in AASHTO LTS-4.
C. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.
   1. Wind speed for calculating wind load for poles exceeding 50 feet (15 m) in height is 110 mph (177 km/h)

1.4 SUBMITTALS
A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.5 ACTION SUBMITTALS
A. Product Data: Provide for each luminaire, pole, and support component, arranged in order of Luminaire Schedule designation. Include data relating to features, accessories, finishes, and the following:
   1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
   2. Details of attaching luminaires and accessories.
3. Details of installation and construction.
4. Luminaire finish and color information.
5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.
   a. Photometric data shall be certified by a qualified independent testing agency.
6. Photoelectric control relays.
7. Ballasts, Power Supplies and Drivers: Provide separate data sheet, per luminaire tag, proving specification and design criteria written herein.
8. Light Source: Provide separate data sheet, per luminaire tag, providing specification and design criteria written herein.
9. Pole and/or support structure data: Provide separate data sheet, per luminaire tag, indicating material(s), dimensions, finishes, accessories, etc. proving specification and design criteria written herein.
10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
11. Pole and support structure anchor bolt information.
12. Pre-manufactured pole foundation information.

B. Shop Drawings:
1. Anchor bolt templates keyed to specific poles and certified by manufacturer.
2. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.

C. Luminaire Samples for Verification: For specific products designated for sample submission in Luminaire Schedule, or herein, provide a fully functional, operating sample with not less than the following:
1. Lamp(s): As specified, install in sample luminaire.
2. Cord and Plug: Wired to luminaire junction box or ballast.
3. 120 VAC ballast (for ballasted luminaires).
4. Delivered with the specified finish/color applied, or submitted with a finish and color sample for evaluation.

D. Finish and Color Samples for Verification: Where designated in the Luminaire Schedule, or herein, provided the following:
1. A factory supplied 3" x 5" sample of the specified finish and color, applied on the specified material.

E. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4 and that load imposed by luminaire has been included in design.

1.6 INFORMATIONAL SUBMITTALS
A. Qualification Data: For agencies providing photometric data for luminaires.
B. Lighting Photometric Performance Calculations:
1. Provide software generated scalable lighting photometry plots indicating numerical illuminance values in contour form, where and as directed.
2. Input data, for the purposes of generating the photometry plots shall indicate the design heights of luminaires, design reflectances for the various wall and grade surfaces, initial lumen rating of the light source used, and design light loss factors including ballast factor, lumen depreciation factor, dirt depreciation factor, and any other light loss factors.

3. Provide summary illuminance data including maximum, minimum, average, and maximum to minimum uniformity ratio across the entire confines of the particular area, or space.

4. Identify the lighting calculation software used to produce the photometry plot, date of plot, input data specified above, company name and individual responsible for producing the calculation.

C. Field quality control test reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires poles luminaire lowering devices to include in emergency, operation, and maintenance manuals.

B. Warranty: Special warranty specified in this Section.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Solid State Lighting/Luminaires:
   1. Luminous flux, luminaire efficiency and chromaticity shall be tested, measured and reported in accordance with the most current versions of IES documents LM-79 and LM-80.
   2. Chromaticity ranges for "white light" products, with various correlated color temperatures, shall be provided in accordance with ANSI/NEMA-C78.377.
   3. Drivers and power supplies shall be provided in accordance with the requirements of ANSI/NEMA-C82.SSL1 and their maximum allowable harmonic emission limits shall be in accordance with ANSI/NEMA-C82.77.
   4. Shall be provided with a U.S. Department of Energy (DOE) "Lighting Facts "label indicating their specific performance characteristics, tested and reported in accordance with the requirements of the most current version of IES LM-79.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


E. Comply with NFPA 70.

F. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
   1. Electrical Acceptance Testing Responsibilities
   2. General Electrical Field Quality Control
   3. Testing Agency Qualifications

1.9 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.
B. Store poles on decay resistant treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch (6 mm) deep. Do not apply tools to section of pole to be installed below ground line.

D. Retain factory applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.

E. Retain factory applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty Period for Luminaires: Five (5) years from date of Substantial Completion.
2. Warranty Period for Luminaire Metal Corrosion: Five (5) years from date of Substantial Completion.
3. Warranty Period for Luminaire Color Retention: Five (5) years from date of Substantial Completion.
4. Warranty Period for fluorescent Lamps: Replace lamps and fuses that fail within 12 months from date of Substantial Completion; furnish replacement lamps and fuses that fail within the second 12 months from date of Substantial Completion.
5. Warranty Period for Poles and Support Structures: Repair or replace poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three (3) years from date of Substantial Completion.
6. Warranties for LED Luminaires: Written warranty, executed by manufacturer agreeing to replace luminaires, including labor, exhibiting a failure of LED modules for LED drivers within five (5) years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with the requirements of this section and the design criteria specified in the Luminaire Schedule, provide products by the manufacturers listed in the Luminaire Schedule.

B. Reference to specific manufacturers and their respective model or series numbers, are included in the Luminaire Schedule to provide a guide as to the level of quality, performance, and overall physical appearance of the specified product, which shall be met, in accordance with the Luminaire Schedule’s design criteria, and as written herein.

C. Listed manufacturers and their series or model numbers shall not imply unconditional specification approval. The listed manufacturers and their respective products have been included as acceptable manufacturers of products which shall comply with the Luminaire Schedule design criteria, luminaire, pole and accessory descriptions, and these specifications. Modification to a given manufacturer’s standard product may be required to make the model or series numbers listed comply with the Luminaire Schedule design criteria, and these specifications.
1. The preceding paragraph shall in no way suggest or indicate that a manufacturer’s UL listing be voided or otherwise compromised, in order to comply with the specified luminaire design criteria, descriptions or these specifications.

D. Products and Accessory Manufacturers: Subject to compliance with the requirements of this section, provide products from the manufacturers included herein.

E. Manufacturers of products not specifically listed in the Luminaire Schedule, or submitting on the basis of "or equivalent", or "as approved", shall provide the following for review prior to, or along with product submission.

1. Documentation showing a minimum of three years experience in the business of the design and manufacture of lighting equipment similar to the type and quality of products specified.
2. Product data and photometry demonstrating conformance with these specifications and the specific data included in the Luminaire Schedule.
3. Prototype and/or operating sample of the product for evaluation by the Architect/Engineer. Prototype and/or sample shall be sufficiently detailed and operational to allow for fair evaluation and to demonstrate compliance with the salient features specified. Product data and shop fabrication drawings are not acceptable means of providing prototype/sample requirement.
4. Architect/Engineer shall be the sole judge of compliance and reserves the right to disapprove manufacturer’s products other than what has been previously specified.

2.2 LUMINAires, GENERAL REQUIREMENTS

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

B. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel.

H. Non Metallic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.
Lenses and Refractors Gaskets: Use heat and aging resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

Luminaire Finish: Except as otherwise noted or specified, manufacturer's standard paint finish applied to factory assembled and tested luminaire before shipping. Where indicated, provide finish process and color specified.

Factory Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

2.3 LUMINAIRES - LED

A. Refer to Luminaire Schedule for specified parameters such as correlated color temperature (CCT) value(s), lumen output, efficiency, etc.

B. Products shall be fabricated to be Reduction of Hazardous Substances (RoHS)-compliant.

C. Must maintain their warrantied life while operating within the manufacturers’ specified environmental parameters.

D. The lumen value specification listed in the Luminaire Schedule is a delivered lumen value specification. Products supplied shall deliver not less than the lumen value specified.

E. The lumen maintenance specification of any assembled LED based chip, array, module, driver, and luminaire combination shall be a minimum of \( L_{70} \), at 50,000 hours, as tested and measured in compliance with IES documents LM-79 and LM-80.

F. Except as otherwise stated in the Luminaire Schedule, the light source shall provide a minimum CRI of 80.

G. Reference Products:
   1. Refer to the Luminaire Schedule.

H. Drivers: Listed and so labeled per UL 8750 and UL 1310, and shall meet or exceed the following general specification criteria:
   1. Designed and tested to be compatible with the luminaire light source operating current, voltage, and output power requirements.
   2. Inaudible above 27 dBA ambient sound level.
   3. Designed, fabricated, and tested to operate at an input voltage of 120 – 277VAC, ±10 percent, at 60 Hz, with no perceptible change in light source output.
   4. Contribute less than 20 percent total harmonic distortion, operating at full rated load, and shall not exceed the maximum allowable THD requirements allowed per standard ANSI C82.11.
   5. Provided with integral short circuit, open circuit, and overload protection.
   6. Have an operating power factor ≥ 0.9.
   8. Housed in a UL compliant and listed enclosure, suitable for remote installation where required, and listed for installation within spaces used for environmental air (plenum), as defined in NFPA-70 – the National Electrical Code.
   9. Manufacturers:
      a. Cree.
      b. EldoLED.
      c. Philips/Advance.
2.4 PHOTOELECTRONIC CONTROLS INTEGRAL TO LUMINAIRE

A. Integral, Luminaire Installed, Photocell:
   1. Where specified, scheduled and or otherwise indicated, provide a photo-electronic device designed, built, and tested to provide automatic, ON/OFF, dusk to dawn control of an individual luminaire, based on ambient daylight level.
   2. Shall be UL 773A listed and fabricated to meet or exceed the requirements of ANSI C136.10, with integral relay contacts rated not less than 1000 VA to a ballasted load at not less than 300VAC.
   3. Provided with integral time delay feature to prevent false operation after momentary light flashes or light blockages.
   4. Reference Product: By luminaire manufacturer

2.5 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

A. Structural Characteristics: Comply with AASHTO LTS-4.
   1. Wind Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in Part 1 "Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.
   2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers’ mounting requirements. Use stainless steel fasteners and mounting bolts, unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
   1. Materials: Shall not cause galvanic action at contact points.
   2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless steel items are indicated.
   3. Anchor-Bolt Template: Plywood or steel.

D. Concrete Pole Foundations: May be cast in place or factory precast.
   1. Refer to drawing details for cast in place foundation dimensional and construction requirements.
      a. Anchor bolts specific to the design of the exterior lighting poles shall be furnished to the contractor for installation and embedment within the pole foundations.
      b. Contractor shall provide raceways, grounding electrodes, and other electric work relating to the pole foundations.
   2. Refer to Division 03 Section "Cast-in-Place Concrete" for earthwork, concrete, reinforcement, formwork, and erection specifications.
   3. Factory precast foundations shall be fabricated to the dimensional and construction requirements indicated on the drawing details.
      a. Anchor bolt specifications, specific to the design of the exterior lighting poles, shall be provided to the precast fabricator for their installation and embedment within the precast pole foundations.
b. Raceway requirements (size, quantity, and locations) shall be provided by the contractor, to the precast fabricator, for installation and embedment with the precast pole foundations.

c. Precast concrete foundation designs shall be engineered by a professional structural engineer, licensed in the locale, and shall be so identified.

E. Power Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.

F. Breakaway Supports: Where indicated on the drawings, provide frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4.

2.6 ALUMINUM POLES

A. Poles: Seamless, extruded structural tube complying with ASTM B 429, Alloy 6063-T6 with access handhole in pole wall.

   1. Shape: Round and tapered unless specified otherwise in Luminaire Schedule.
   2. Erection Provisions: Butt flange for bolted installation on foundation or breakaway support.

C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

D. Handhole: Provide handhole opening, nominal 3" x 5", at approximately 18" above pole base, complete with weathertight cover and securing fastener.

E. Grounding and Bonding Lugs: Welded ½ inch (13 mm) threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding " listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

F. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, and then bolted together with stainless steel bolts.
   1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
   2. Finish: Same as luminaire.

G. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

H. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

2.7 IN-LINE FUSING

A. Shall be UL listed and labeled, single pole, 600VAC, breakaway style, in-line fuse holders, designed for field installation onto pole supported luminaires.

B. Shall be two part device, consisting of water resistant type lineside and loadside mechanical crimp connector terminals to accept stranded or solid conductors, with insulating boots, designed to accept midget size fuses up to 30A.

C. Provide complete with fuses, sized to the specific load.
PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Install exterior lighting and their related accessories in accordance with the respective luminaire manufacturer’s instructions and the applicable requirements of the NEC, NECA/IESNA 501 – “Standard for Installing Exterior Lighting Systems”, NEMA standards, and with recognized industry practices.

B. Coordinate layout and installation of luminaires with the work of other construction.

C. Provide light source(s) in each luminaire.

D. Supports:
   1. Sized and rated for luminaire weight and physical construction.
   2. Provided to maintain luminaire position after cleaning and service.
   3. Provided to support luminaires without causing deflection of the finished surface upon which the luminaire is installed.
   4. Luminaire installation method and devices shall provide for a horizontal force of not less than 100 percent of luminaire weight, and a vertical force of not less than 400 percent of luminaire weight.

E. Wiring:
   1. Install all wiring in raceways.
   2. Comply with the requirements of Division 26 Sections "Low Voltage Electrical Power Conductors and Cables", "Raceways", and "Boxes and Cabinets".

F. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources.

G. Provide box wiring identification per Division 26 Section "Electrical Identification."

3.2 POLE INSTALLATION

A. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features, unless otherwise indicated on Drawings:
   1. Fire Hydrants and Storm Drainage Piping: 60 inches (1520 mm).
   2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet (3 m).
   3. Trees: 15 feet (5 m).

C. Refer to drawing details for additional information regarding foundation dimensions, projections above grade, and other site specific criteria.

D. Site Fabricated, Cast in Place, Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."
E. Precast Concrete Pole Foundations:
   1. Follow the precast concrete foundation fabricator’s handling and erection directions for installation.

F. Foundation Erected Poles: Install pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
   1. Erect and secure poles to foundations, plumb and level.
   2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
   3. Install base covers, unless otherwise indicated.
   4. Use a short piece of 1/2-inch (13-mm) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

G. Poles and Pole Foundations Set in Concrete Paved Areas: Except as otherwise noted, install poles with minimum of 6-inch (150 mm) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.

H. Raise and set poles using web fabric slings (not chain or cable).

3.3 BOLLARD LUMINAIRE INSTALLATION
   A. Refer to drawing details for additional installation requirements.
   B. Align units for optimum directional alignment of light distribution.
   C. Except as otherwise noted, install on concrete base with top 4 inches (100 mm) above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES
   A. Refer to drawing details for additional installation requirements.
   B. Except as otherwise noted, install on concrete base with top 4 inches (100 mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION
   A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
   B. Steel Conduits: Comply with Division 26 Section "Raceway." In concrete foundations, conduits shall be coated with an approved asphaltic paint, plastic coating or shall be wrapped with a single layer of a pressure-sensitive plastic tape, half lapped.
3.6 GROUNDING AND BONDING

A. Bond metal poles and support structures according to Division 26 Section "Grounding and Bonding."
   1. Install a grounding electrode at each pole, unless otherwise indicated.
   2. Install a grounding electrode conductor at the base of each pole, bonded to the branch circuit equipment ground conductor.

B. Bond nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding."
   1. Install a grounding electrode for each pole.
   2. Install a grounding electrode conductor and conductor protector.
   3. Ground metallic components of pole accessories and foundations.

3.7 FIELD QUALITY CONTROL

A. Inspections and Tests:
   1. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing", ANSI/NETA ATS "System Functional Tests" and "Thermographic Survey" requirements, and the following additional requirements:
      a. Follow-up thermographic survey shall not be required.
      b. Prepare test and inspection reports.
      c. Inspect each installed fixture for damage. Replace damaged fixtures and components.
      d. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
         1) Verify operation of photoelectric controls.
      e. Illumination Tests:
         1) Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):
            a) IESNA LM-5, "Photometric Measurements of Area and Sports Lighting."
            b) IESNA LM-50, "Photometric Measurements of Roadway Lighting Installations."
            c) IESNA LM-64, "Photometric Measurements of Parking Areas."
            d) IESNA LM-72, "Directional Positioning of Photometric Data."
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<td>Cooper</td>
<td>XTOR3B (Base Fixture)</td>
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<td>Cooper</td>
<td>ISW-SA1-A-XXX-U (Base Fixture)</td>
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END OF SECTION 265600
PART 1 - GENERAL

1.1 SUMMARY
   A. This Section provides specifications and design criteria for aviation lighting equipment.

1.2 REQUIREMENTS
   A. All luminaires, supports, hardware, raceways, wiring, light sources, and accessories to provide artificial illumination and identification of obstructions, approach and departure paths, wind indicators, and touchdown pads for aircraft personnel.

1.3 REFERENCES

1.4 SUBMITTALS
   A. General: Submit the following in accordance with Division 26 Section "Basic Division 26 Requirements."

1.5 ACTION SUBMITTALS
   A. Product Data: Provide for each device. Include bill of materials, manufacturer's installation instructions, listing data, wiring diagrams and enclosure sizes.

1.6 QUALIFICATIONS
   A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three (3) years documented experience, and listed in FAA AC 150/5345-53 (Current Edition), Appendix 1, Addendum.

1.7 QUALITY ASSURANCE
   A. Field Testing: Refer to Division 26 Section "Electrical Inspections and Testing" for field inspections and testing requirements related to this Section including:
      2. General Electrical Field Quality Control.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with the requirements of this section, provide products by the manufacturers listed.

B. Reference to specific manufacturers and their respective model or series numbers, are included, to provide a guide as to the level of quality, performance, and overall physical appearance of the specified product, which shall be met, in accordance with the design criteria, and as written herein.

C. Listed manufacturers and their series or model numbers shall not imply unconditional specification approval. The listed manufacturers and their respective products have been included as acceptable manufacturers of products which shall comply with the design criteria, luminaire descriptions, and these specifications. Modification to a given manufacturer’s standard product may be required to make the model or series numbers listed comply with the design criteria, and these specifications.

1. The preceding paragraph shall in no way suggest or indicate that a manufacturer’s UL listing be voided or otherwise compromised, in order to comply with the specified design criteria, descriptions or these specifications.

D. Manufacturers of products not specifically listed and submitting on the basis of “or equivalent”, or "as approved", shall provide the following for review prior to, or along with product submission.

1. Documentation showing a minimum of three years' experience in the business of the design and manufacture of equipment similar to the type and quality of products specified.
2. Product data and photometry demonstrating conformance with these specifications and the specific data included herein.
3. Prototype and/or operating sample of the product for evaluation by the Architect/Engineer. Prototype and/or sample shall be sufficiently detailed and operational to allow for fair evaluation and to demonstrate compliance with the salient features specified. Product data and shop fabrication drawings are not acceptable means of providing prototype/sample requirement.
4. Architect/Engineer shall be the sole judge of compliance and reserves the right to disapprove manufacturer’s products other than what has been previously specified.

2.2 RED OBSTRUCTION LIGHTS - STEADY "ON"

A. Description: Steady-burning, red, single lamp head design, 120VAC LED light source, FAA L-810 certified, tested, and labeled.

B. Specifications:

1. Lamp Head Design: Cast aluminum construction, listed and labeled Suitable for Use in Wet Locations in accordance with UL1598 2; UL50, and applicable portions of CSA C22.2, with stainless steel fasteners and hardware.
2. Entire lighting unit shall be finished in a corrosion and weather resistant polyester powder coat, and shall be certified by the manufacturer to comply with the US Military Standard Salt Fog Test conducted per MIL-STD-810 (Current Issue), Method 509.5.
3. Light Source: LED, meeting or exceeding the chromaticity and photometric performance requirements of FAA Advisory Circular AC 150/5345-43 (Current Issue), and shall provide an average life of not less than 70,000 hours.
4. Colored Globe/Diffuser: Soda lime glass, red in color, providing 360 degree visibility, sealed and gasketed to lamp head base.
5. Provided with an integral cast aluminum junction box, with threaded hubs for raceway connections, containing an integral alarm reporting terminal device.
   a. Upon light source failure, an isolated "dry" (voltage free) relay contact closure shall provide an "alarm" output, to be monitored via a remote alarm circuit.

6. Provide complete with required hardware, brackets, fittings, accessories, etc., for attachment to building structure, pole top, tower framing, electrical raceways, cables, etc.

C. Referenced Products:
   3. Point Lighting Corp. - POL LED v3 Series.

2.3 RED OBSTRUCTION BEACONS - FLASHING

A. Description: Flashing beacon style luminaire, red, single beacon design, 120VAC LED light source, FAA L-864 certified, tested, and labeled.

B. Specifications:
   1. Beacon Design: Cast aluminum construction, listed and labeled Suitable for Use in Wet Locations in accordance with UL1598 2; UL50, and applicable sections of CSA C22.2, with stainless steel fasteners and hardware.
   2. Entire lighting unit shall be polyester powder coat finished in aviation yellow, and shall be certified by the manufacturer to comply with the US Military Standard Salt Fog Test conducted per MIL-STD-810 (Current Issue), Method 509.5.
   3. Light Source: White or red LED, meeting or exceeding the chromaticity and photometric performance requirements of FAA Advisory Circular AC 150/5345-43 (Current Issue), and shall provide an average life of not less than 70,000 hours.
   4. Flash Rate and Duration Characteristics: Per FAA Advisory Circular AC 150/5345-43 (Current Issue), Table 4.
      a. Where multiple beacon locations are designed at the same site, provide a flash synchronization module to synchronize the flashes of all beacons within the established requirement of FAA Advisory Circular AC 150/5345-43 (Current Issue).
   5. Colored Globe/Diffuser: Red or clear, soda lime glass or UV resistant polycarbonate, providing 360 degree visibility, sealed and gasketed to beacon base.
   6. Provided with an integral cast aluminum junction box, with threaded hubs for raceway connections, containing an integral alarm reporting terminal device.
      a. Upon light source failure, an isolated "dry" (voltage free) relay contact closure shall provide an "alarm" output, to be monitored via a remote alarm circuit.
      b. Where specified as a double beacon design, the primary beacon shall be stacked on top of the secondary/standby beacon.
   7. Provide complete with required hardware, brackets, fittings, accessories, etc., for attachment to building structure, pole top, tower framing, electrical raceways, cables, etc.

C. Referenced Products:
   3. Point Lighting Corp. - PFB LED Series.
2.4 OBSTRUCTION LIGHT PHOTOELECTRONIC CONTROL
A. Photoelectronic type light sensing device and contactor, designed to the requirements of FAA Advisory Circular AC 150/5345-43 (Current Issue), to control obstruction lighting equipment ON/OFF, based on ambient daylight conditions.
B. Housed in an outdoor, weatherproof, cast aluminum outlet box with threaded hubs for raceway installation.
C. Provide for field connection of not less than two, 30A branch circuits, @ 2400 watts per circuit, at 120VAC.
D. Provided with integral surge protection.
E. Referenced Products:
   3. Point Lighting Corp. - PPC 40000 Series.

2.5 OBSTRUCTION LIGHTING CONTROLLER
A. Obstruction lighting shall be automatically controlled and monitored by means of an controller designed, fabricated, and tested to comply with FAA Advisory Circulars 70/7460-1 (Current Issue) and 150/5345-43 (Current Issue).
B. Provide a 30-amp contactor (power relay) for turning the connected lighting units ON/OFF, activated by photoelectronic control device.
C. Lighting circuit outputs shall be protected by current limiting overcurrent protective devices:
   1. DIN-rail mounted, current limiting, 15-amp circuit breakers providing thermal magnetic overcurrent protection in accordance with UL, CSA and IEC standards.
   2. IEC rated short circuit rating of not less than 10,000 amps.
   3. Breakers shall be resettable, and their TRIP status shall be so indicated.
D. Provide not less than the following features, devices, components, etc.:
   1. Wiring terminals for AC power in/out, remote photoelectronic control device connection, and terminals for remote connection of alarm contacts.
   2. A solid-state, encapsulated beacon flasher, prewired to output terminal blocks.
   3. A flasher bypass relay designed and connected to keep the steady-burning lighting units ON, upon flasher failure.
   4. Isolated, contact terminals for:
      a. Steady ON obstruction light failure alarm.
      b. Beacon failure alarm.
      c. Beacon flasher failure alarm.
   5. Metal oxide varistor (MOV) surge suppression protection for the flasher module.
   6. A green LED "Power ON" pilot light, indicating the presence of AC power, shall be provided on face of door.
   7. A three (3) position ON-OFF-AUTO override switch of the photoelectronic ON/OFF control device, to allow manual operation of obstruction lighting for maintenance purposes, shall be provided on face of door.
   8. Alarm pilot lights, each individually labeled, for each "alarm" condition.
E. Enclosure shall be fiberglass, rated NEMA 4X, with hinged, lockable door, and seamless gasketing at opening.
   1. Previously described devices and components shall be factory installed to internal metal panel.
   2. The enclosure may be field punched or drilled for raceway entries/exits.
   3. Internal wiring and component spacing shall comply with the National Electric Code.

F. Referenced Products:
   2. Flight Light, Inc. - 9LC Series.
   3. Point Lighting Corp. - POC Controller Series.

2.6 HELIPORT TLOF MARKER LIGHT

A. Inset (Flush) Style: A 2-piece design, consisting of a separate backbox assembly, and a separate optical assembly, designed, fabricated, tested, and ETL certified to FAA L-860HS Advisory Circular AC 150/5345-46 (Current Edition), and FAA Airports Engineering Brief 87 - Helicopter Perimeter Light for Visual Meteorological Conditions.
   1. Backbox Assembly: Cast aluminum construction, designed, fabricated, and tested for direct burial installation into raised, or at grade Touchdown and Liftoff Area (TLOF) paving surface, with treaded hub style raceway attachment point.
      a. Sealed watertight, and shall contain terminations for 120VAC, 60 Hz, electrical power supply for optical assembly.
      b. Provide pressure testing plug for seal integrity verification.
   2. Optical Assembly: Heavy cast aluminum construction, nom. 12 inch dia., fastened to backbox assembly with watertight mechanical seal and stainless steel hardware set flush to surface.
      a. LED light source meeting or exceeding the photometric requirements documented in AC 150/5345-46 (Current Edition), and providing not less than 100,000 hrs. average life.
      b. FAA Style 1 - Low Protrusion profile above TLOF final elevation.
      c. Green glass lens.
   3. Luminaire Surfaces: Provided with a corrosion resistant, polyester powder coat finish meeting or exceeding the requirements of MIL-STD-810 (Current Edition), Method 509.
   4. Referenced Products:
      c. Point Lighting Corp. - PRL LED Series.

B. Elevated (Raised, Omni-Directional) Style: A 2-piece design, consisting of a separate lamp head assembly, and a separate mounting base, designed, fabricated, tested, and ETL certified to FAA L-860HR Advisory Circular AC 150/5345-46 (Current Edition), and FAA Airports Engineering Brief 87 - Helicopter Perimeter Light for Visual Meteorological Conditions.
   1. Lamp Head Assembly: Heavy cast aluminum construction, designed, fabricated, and tested for exposed, surface installation onto raised Touchdown and Liftoff Area (TLOF) paving platform, with treaded hub style stanchion.
a. LED light source meeting or exceeding the photometric requirements documented in AC 150/5345-46 (Current Edition), and providing not less than 100,000 hrs. average life.
b. Sealed, watertight assembly.
c. LEDs and/or lamp head glass globe shall be green, meeting or exceeding the photometric requirements documented in AC 150/5345-46 (Current Edition).
d. FAA Style 1 - Low Protrusion profile above TLOF final elevation.
e. Terminations for 120VAC, 60 Hz, electrical power supply for optical assembly.

2. Base Assembly: Fabricated from heavy cast aluminum construction, and shall provide for the vertical support of the lamp head assembly, and shall provide the mounting and installation provisions required to secure the entire assembly to the TLOF structure.

3. Luminaire Surfaces: Provided with a corrosion resistant, polyester powder coat finish meeting or exceeding the requirements of MIL-STD-810 (Current Edition), Method 509.

4. Referenced Products:
   c. Point Lighting Corp. - PEL LED v4 Series.

2.7 HELIPORT FATO MARKER LIGHT

A. Inset (Flush) Style: A 2-piece design, consisting of a separate backbox assembly, and a separate optical assembly, designed, fabricated, tested, and ETL certified to FAA L-860HS Advisory Circular AC 150/5345-46 (Current Edition), and FAA Airports Engineering Brief 87 - Helicopter Perimeter Light for Visual Meteorological Conditions.

1. Backbox Assembly: Cast aluminum construction, designed, fabricated, and tested for direct burial installation into raised, or at grade Final Approach and Takeoff Area (FATO) paving surface, with treaded hub style raceway attachment point.
   a. Sealed watertight, and shall contain terminations for 120VAC, 60 Hz, electrical power supply for optical assembly.
   b. Provide pressure testing plug for seal integrity verification.

2. Optical Assembly: Heavy cast aluminum construction, nom. 12 inch dia., fastened to backbox assembly with watertight mechanical seal and stainless steel hardware set flush to surface.
   a. LED light source meeting or exceeding the photometric requirements documented in AC 150/5345-46 (Current Edition), and providing not less than 100,000 hrs. average life.
   b. FAA Style 1 - Low Protrusion profile above FATO final elevation.
   c. Green glass lens.

3. Luminaire Surfaces: Provided with a corrosion resistant, polyester powder coat finish meeting or exceeding the requirements of MIL-STD-810 (Current Edition), Method 509.

4. Referenced Products:
   c. Point Lighting Corp. - PEL LED Series.

B. Elevated (Raised, Omni-Directional) Style: A 2-piece design, consisting of a separate lamp head assembly, and a separate mounting base, designed, fabricated, tested, and ETL certified to FAA L-860HR Advisory Circular AC 150/5345-46 (Current Edition), and FAA Airports Engineering Brief 87 - Helicopter Perimeter Light for Visual Meteorological Conditions.
1. Lamp Head Assembly: Heavy cast aluminum construction, designed, fabricated, and
tested for exposed, surface installation onto raised Final Approach and Takeoff Area
(FATO) paving platform, with treaded hub style stanchion.
   a. LED light source meeting or exceeding the photometric requirements documented
      in AC 150/5345-46 (Current Edition), and providing not less than 100,000 hrs. 
      average life.
   b. Sealed, watertight assembly.
   c. LEDs and/or lamp head glass globe shall be green, meeting or exceeding the
      photometric requirements documented in AC 150/5345-46 (Current Edition).
   d. FAA Style 1 - Low Protrusion profile above FATO final elevation.
   e. Terminations for 120VAC, 60 Hz, electrical power supply for optical assembly.

2. Base Assembly: Fabricated from heavy cast aluminum construction, and shall provide for
   the vertical support of the lamp head assembly, and shall provide the mounting and
   installation provisions required to secure the entire assembly to the TLOF structure.

3. Luminaire Surfaces: Provided with a corrosion resistant, polyester powder coat finish
   meeting or exceeding the requirements of MIL-STD-810 (Current Edition), Method 509.

4. Referenced Products:
   c. Point Lighting Corp. - PEL LED v4 Series.

2.8 HELIPORT LANDING DIRECTION MARKER LIGHT
A. Shall be similar in design and specification to FATO inset (flush) marker lights (Symbol Subscript AA7).

2.9 HELIPORT IDENTIFICATION ROTATING BEACON
A. Designed, fabricated, and tested to FAA Advisory Circular AC 150/5345-12 (Current Edition).
B. FAA classified as Type L-801H designed as identification and location markers for heliports.
C. Three lamp head, rotating beacon style luminaire, providing alternating white/green/yellow color
   flashes, at a flash rate between colors of 30 to 45 flashes per minute.
   1. Provided with one clear, one aviation green, and one yellow lens.
   2. Lens Material: Heat resistant glass, meeting the requirements of MIL-STD C-7989 (Current
      Edition).
   3. Lamping: As required to meet the FAA classification specified above, and shall provide
      the photometric requirements of AC 150/5345-12 (Current Edition), and shall be rated for
      not less than 12,000 hour typical lamp life (3 years).
   4. Lamp Head Aiming: Field adjustable, from 2 to 10 deg. above horizontal, and luminaires
      shall have calibration marks in 1 deg. increments to aid in adjustment.
D. Drive Motor: 120VAC, 60Hz. Motor and drive components shall be specifically designed,
   fabricated, and tested to meet or exceed the environmental requirements of AC 150/5345-12
   (Current Edition).
E. An outdoor, weatherproof, metal enclosure shall be provided to house all beacon components.
   Enclosure shall be:
   1. FAA Rated Class I Temperature Range: -30 to +55 °C (-22 to +131 °F).
   2. Designed, fabricated and tested to withstand wind velocities of not less than 100 mph.
   3. Provided with corrosion resistant, polyester powder coat finish.
F. Referenced Products:
   2. Flight Light, Inc. - L-801H/L-802H Series.
   3. Hali-Brite - HBM 150/3 Series.

2.10 HELIPORT LIGHTED WIND CONE ASSEMBLY

A. Wind cone assembly shall include a wind sock, hinged pole, floodlighting to externally illuminate the wind sock and obstruction beacon.

B. Wind Sock: Open ended, tapered, reinforced nylon sock, aviation orange in color, nom. 8 ft. long, with an 18 inch throat diameter (at pole end), designed, fabricated, and tested to FAA L-807, Size 1 requirements.
   1. A rigid frame shall hold sock out perpendicular from pole (3/8ths of total sock length), and shall allow sock to rotate around pole, indicating wind direction.
   2. All anchoring and wind direction hardware shall be fabricated from stainless steel hardware, and shall be permanently lubricated, or provided with fittings to allow for periodic lubrication.
   3. Wind sock must move freely about pole assembly, and shall provide true wind direction within +/- 5 deg. when subjected to a wind velocity of not less than 3 knots (3.5 mph).

C. Pole Assembly: Round, tapered steel pole design, hinged at base for lowering, serviceable from grade, provided complete with wiring hand hole, and accessories for installation of wind sock, floodlighting, and obstruction beacon.
   1. Overall pole height shall be 22 feet 6 inches, with wind sock assembly installed at 16 feet, and floodlights and beacon at top.
   2. Pole shall be corrosion resistant primed, and finish coated in aviation orange, polyester powder coats.
   3. Shall be provided with removable hinged pin, and permanently attached rope style winch for lowering purposes.
   4. Provide vibration damper internal to pole to mitigate harmonic resonance.

D. Lighting Assembly: Per FAA Style 1-A (externally lighted) and shall include an outdoor, weatherproof, cast aluminum, luminaire(s) and a single obstruction light.
   1. Sock Lighting Luminaire(s): LED light source(s) for external cone illumination. Quantity, style, and performance to meet or exceed the illumination requirements of FAA document AC 150/5345-27 (Current Edition).
   2. Obstruction Light: Steady ON, red lamp head assembly, conforming to FAA document 150/5345-43 (Current Edition), Type L-810, installed at the very top of pole assembly.

E. Referenced Products:
   1. Cooper/Crouse-Hinds - WC Series (Modified per these specification requirements).
   2. Flight Light, Inc. - L-801H/L-802H Series.
   3. Hali-Brite - L-807 Series.
   4. Point Lighting Corp. - PWC LED Series.

2.9 HELIPORT LIGHTING CONTROLLER

A. Heliport lighting shall be controlled automatically by means of a complete system controller. All controller components shall be factory installed in a NEMA 4X (IP66) fiberglass enclosure with stainless steel piano hinged door, and full perimeter seamless gasket.
   1. The door shall be secured with lockable latch.
2. All internal components shall be panel mounted.

B. Components shall be prewired to IEC terminal blocks.

C. The controller and lighting circuits shall be protected from transient voltage spikes by a DIN-rail mounted MOV type 100kA interrupting surge suppressor with UL and IEC approval.

D. There shall be industrial grade pilot lights factory installed on face of door:
   1. Green: Power On indicating power is present at the input terminals of the contactor.
   2. Amber (yellow): System On indicating that the unit is activated and power is available to the loads.

E. All components installed on door shall be NEMA 4 rated for outdoor installation.

F. A three (3) position master switch shall be factory installed on face of door for ON-OFF-AUTO operation.
   1. In the AUTO position, the controller shall operate automatically from a FAA photoelectric controller that operates per FAA light level requirements.
   2. The controller shall include ON-OFF two-position switches factory installed on face of door, designating specific lighting loads. These switches shall be field connected to independently control separate circuits as determined.
   3. Power to these circuits shall be controlled by the master switch.

G. Each load output circuit shall be protected by a DIN-rail mounted current limiting 15-amp circuit breaker providing thermal magnetic overcurrent protection in accordance with UL, CSA and IEC standards.

H. Referenced Products:
   3. Point Lighting Corp. - PHC Series.

PART 3 - EXECUTION

3.1 GENERAL

A. Install aviation lighting in locations as shown on Drawings complete with light sources and accessories.

B. Install obstruction lighting controller approximately where indicated, at a height of 6 feet to top of enclosure.

C. Install photocells at or near the highest point of the structure, away from artificial light sources, and clear of shadows or obstructions that may cause false or premature triggering of daylight or dusk set points.

3.2 INSTALLATION - OBSTRUCTION LIGHTS

A. Attach luminaires securely to building, square, plumb, and true to building construction.

B. Verify locations and installation heights of luminaires prior to roughing. Observation lights shall be installed with no obstructions, appurtenances, structures, or other objects limiting their visibility.

C. Wiring for the connection of obstruction lighting, and its associated controls, shall be installed in galvanized rigid steel raceway where routed outside the building.
D. Follow manufacturer’s directions for installation and wiring

E. Minimum wire size for connection of obstruction lighting and its associated control equipment, shall be not less than #12 AWG. Voltage drop allowed for connection of obstruction lighting shall be less than 3 percent of supply voltage.

F. Splicing of wiring at other than the luminaire’s integral junction box, or at its control device, is prohibited.

3.3 INSTALLATION - HELIPORT LIGHTING

A. Follow manufacturer’s directions for installation and wiring.

B. Verify exact locations of luminaires prior to roughing.

C. Wiring for the connection of heliport lighting, and its associated controls, installed outside the building, either exposed or below grade, shall be installed in galvanized rigid steel raceway.
   1. Lengths of liquidtight flexible metal conduit, not longer than 72 inches in length, may be used as a final wiring method between an outlet box installed near the luminaire, and the remainder of the raceway run.

D. Minimum wire size for connection of heliport lighting and its associated control devices and equipment, shall be not less than #12 AWG. Voltage drop allowed for the connection of heliport lighting shall be less than 3 percent of supply voltage.

E. Splicing of wiring at other than the luminaire’s integral junction box, or at its associated control device, is prohibited.

F. Attach elevated luminaires securely to the raised heliport structure, square, plumb, and true to its construction.

G. Inset luminaires designed for flush to grade installation shall be set into concrete foundations poured flush to grade.

3.4 INSTALLATION - LIGHTED WIND CONE ASSEMBLY

A. Verify exact location with Architect prior to roughing.

B. Wind cone support structure shall be securely anchored to building, or to sub-surface concrete foundation at grade.

3.5 ADJUSTING

A. Adjust work under provisions of Division 01 requirements.

B. Adjust flash rate and photocell level setpoints to meet requirements of FAA.

3.6 FIELD QUALITY CONTROL

A. Perform inspections and test procedures as required by Division 26 Section "Electrical Inspections and Testing":
   1. Prepare test and inspection reports.

B. Test each luminaire and its associated control for proper operation.

C. Test, document, and report voltage drop readings at each luminaire location, proving conformance with this specification.
D. Test communication links between control panels and remote monitoring locations, proving conformance with this Specification.

E. Test for proper operation of photoelectric controls and their associated control panels.

END OF SECTION 265690
PART 1 - GENERAL

1.1 EFFECTIVE DATE
   A. This document is version 7.0, issued January 1, 2024.

1.2 SUMMARY
   A. The purpose of this document is to provide a guideline for the standardization of Telecommunications system components and processes for Froedtert Health System.

   B. This standard specifies the basic requirements for telecommunications equipment and spaces for installing or servicing cable and related hardware for Froedtert Health System. This document also establishes a basic list of requirements for the quality processes to be used by contractors and is not meant to be all-inclusive.

   C. This document applies to any contractor or company pre-approved by Froedtert Health IT to providing installation services for telecommunications cable systems, spaces or equipment for Froedtert Health IT System. Other obligations and responsibilities may apply per contract or other agreement. This document does not supersede any such contracts or agreements but may be used as reference to provide clarification or support to those requirements.

   D. All the requirements within this document are defined to be applicable to most situations. This is meant to be the minimum standard by which all construction design documentation and/or installation work should be based. Froedtert Health Information Systems must approve any modifications to these standards prior to being implemented.

1.3 DEFINITIONS
   A. “TELECOMMUNICATIONS” refers to any data, voice, telephone, video, biomedical or related systems.

   B. “CONTRACTOR” refers to all companies, contractors, sub-contractors or other Pre-Approved entities installing telecommunications cabling and/or related equipment for Froedtert Health Systems.

   C. “FHITNM” refers to Froedtert Health IT Network Manager.

   D. “IT” refers to Information Systems Technology Department.

   E. “TR” refers to Telecommunications Room.

   F. “ER” refers to Equipment Room.

   G. “BET” refers to Building Entrance Terminal.

   H. “RU” refers to rack units.

   I. “PTP” refers to point to point cables.

1.4 SCOPE OF WORK
   A. Contract drawings, schedules, documents, and work order will detail the extent of the telecommunications system cabling and equipment installation.
B. The responsibilities of the contractor:

1. Contractor shall Quoted/Propose the project as shown and specified on the drawings, specifications, and associated documents.

2. Contractor shall furnish and install all cable trays, conduits, cables, cable supports, wall plates, connectors, patch panels, patch panel organizers, equipment racks, equipment shelves, and/or other related telecommunications equipment as detailed on drawings, specifications, schedules, and contract documents.

3. All discrepancies found on drawings, specifications and schedules shall be brought to the attention of the FHITNM for correction and/or clarification. No discrepancy or omission from any drawing or specification shall release the contractor from furnishing any services, materials or equipment detailed in the drawings, specifications, schedules, or work order.

4. Contractor shall document any deviation, substitution or alteration from the drawings and specifications; and submit as an alternate to the bid with the amount of difference (deduction or addition) to the base bid specified.

5. Any approval of requests for substitution of products, processes, or procedures above and beyond what is outlined in the specifications shall be the sole decision of the FHITNM.

6. Signoff and approval by the FHITNM are required on all drawings and specifications prior to any work being completed.

1.5 QUALITY ASSURANCE

A. Contractor is required to be qualified and experienced telecommunications contractor to perform design, installation and project management services for the construction and installation of telecommunications infrastructure and equipment. Froedtert Health wants to ensure that successful contractors have the manufacturer certifications, authorizations, capabilities, qualifications, financial stability, and experience to complete the telecommunications installations using common industry practices (BICSI, ANSI, TIA, EIA, NEMA, NFPA, AVIXA, etc.) while adhering to Froedtert Health guidelines.

1. The contractor bidding on the telecommunications systems specified shall be a current CommScope Certified Contractor. Contractor must be able to install, service and warranty the specified product. The contractor’s certificate must be submitted with project proposal/quote. Manufacturer certifications shall not be project specified and should be valid for any and all projects completed by the contractor. All of Froedtert’s qualified contractors shall be afforded the opportunity to bid on all Froedtert projects.
   a. Pre-qualified bidders consist of the following:
      1) CC&N (Communications, Cabling & Networking).
      2) Staff Electric Co Inc.
      3) NEXT Electric, LLC.
      4) Faith Technologies Inc.

2. All required certifications and registrations shall be maintained throughout the duration of the project.
   a. Sumitomo Certified project requiring Air Blown Fiber Installation.
3. The contractor shall have a currently certified BICSI RCDD on staff as a full-time employee. The RCDD shall be responsible to the FHITNM for all work performed by the contractor and/or subcontractors.

4. The project foreman shall be approved by the FHITNM and shall be currently registered BICSI Information Transport Systems (ITS) Technician or an FHITNM approved equal with a minimum of five years of experience.

5. Contractor shall maintain technicians and tradesman with currently registered BICSI ITS Technician or BICSI ITS Installer 2 or FHITNM approved equal for all work under this specification.

6. All apprentices or tradesman with two years or less experience shall be directly supervised by ITS Tech or tradesman with five years or more experience. Proof of manufacturer and BICSI certifications shall be provided to FHITNM at any time of request.

7. If the contractor does not meet all the qualifications in accordance with this document, the contractor shall hire a sub that meets these qualification requirements for the project and approved by the FHITNM.

1.6 WARRANTY AND GUARANTEE

A. The contractor shall submit all the required as-built documentation and test results for all manufacturer warranties. Once submitted and approved, the contractor shall forward the signed warranty registration form and warranty certificate to the FHITNM.

The contractor shall also provide as built documentation to FHITNM.

B. The contractor shall guarantee all other equipment to be free from inherent defects in design, workmanship and material. Equipment shall function properly and continuously under all operating conditions required and/or specified in the contract documents.

C. The contractor shall replace any equipment or component found defective upon delivery or within warranty period from date of final inspection and acceptance by the FHITNM. This shall be done at no expense to the FHITNM.

1.7 REGULATORY REFERENCES

A. The contractor must comply with the latest versions of all applicable codes and industry standards, including all national, state and local codes.

1. NFPA
2. NEMA
3. TIA/EIA
4. ANSI
5. IEEE and ISO
6. UL

PART 2 - PRODUCTS

2.2 GENERAL

A. Products pre-approved by the FHITNM for this specification are listed in the Appendix A of this document. Any deviation from the pre-approved product list required prior approval from the FHITNM.

B. Approved manufacturer components shall be of the latest type and design.
2.3 GROUNDING AND BONDING

A. Products of types, sizes and ratings indicated are to comply with NEC. Any place where types, sizes, ratings and quantities indicated are in excess of NEC requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.

B. Wire and cable conductors are to comply with Division 26 outlined sizing requirements.

C. Solid copper conductor for No 8 AWG or smaller, and stranded conductors for No 6 AWG or larger shall be installed, unless otherwise noted in the construction package.

D. Grounding Busbars

1. Busbars shall be UL listed and meet the requirements of ANSI-5-STD 607.

2. Telecommunications Main Grounding Busbar (TMGB) shall be a minimum 24" W x 4" H x ¼" D electro tin plated copper bus with two rows of predrilled holes on 1 inch centers for ¼ inch bolts. The busbar shall be insulated from its support and separated from the wall by 2 inches.

3. Telecommunications Grounding Busbar (TGB) shall be a minimum 12" W x 4" H x ¼" D electro tin plated copper bus with two rows of predrilled holes on 1-inch centers for ¼ inch bolts. The busbar shall be insulated from its support and separated from the wall by 2 inches.

E. Connectors

1. Bolted Lugs for conductors shall be copper or copper alloy, listed non-reversible compression-type with at least two bolts.

2. Welded Connectors shall be exothermic welding kit of types recommended by kit manufacturer for materials being joined and installation conditions.

F. Grounding Electrodes

1. Grounding rods shall be copper-clad steel with high strength steel core and electrolytic grade copper outer sheath, molten welded to core. Rods are to be ¾ inch diameter by 10 feet long.

2. Plate electrodes shall be copper plates that are a minimum 0.10 inch thick. Size as indicated in project documents.

3. Chemical enhanced grounding electrodes are to be copper tube, straight or L-shaped, charged with non-hazardous electrolytic chemical salts.
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a. Termination to be factory-attached No 4/0 AWG bare conductor at least 48 inches (1200mm) long.

b. Electrode manufacturer’s recommended material is to be used for the backfill material.

G. Antioxidant Joint Compound

1. A synthetic base compound with suspended copper particles must be used.

H. Building Entrance Terminals

1. BET are to be selected with features as follows:
   a. 110 Insulation Displacement Contact (IDC) connector input and output.
   b. Wall mountable.
   c. Vertically stackable.
   d. Shall have external ground lug for building or connecting additional units.

2.4 WIRE BASKET TYPE CABLE TRAYS

A. Cable tray systems shall be of indicated types, sizes and NEMA classes and shall be complete with manufacturer’s recommended covers, barrier strips, dropouts, fittings, conduit adaptors, hold-down devices, grommets and blind ends as required and indicated.

B. Cable tray equipment shall include pre-manufactured bends, tees, intersections, etc. Field modifications of tray will not be acceptable.

C. Cable tray products shall have rounded edges and smooth surfaces.

D. In most typical sites basket tray is used in hallways and ladder tray in used in MDF or IDF rooms, unless otherwise dictated by the FHITNM.

E. Cable tray material shall be carbon steel wire, ASTM A 510, Grade 1008; wire welded, bent and surface treated after manufacturer. Cable tray must be UL rated as a grounding conductor.

F. Cable tray finish for carbon steel wire after welding and bending of mesh shall be powder coat finish in accordance with AAMA 2604; eliminates VOCs in atmosphere during manufacturing process.

G. Cable tray shall consist of continuous, rigid, welded steel wire mesh cable management system, to allow continuous ventilation of cables and maximum dissipation of heat, with UL classified splices where tray acts as equipment grounding conductor. Wire mesh cable tray shall have continuous welded top side wire to protect cable insulation and installers.

1. Cable tray shall only consist of radial bends allowing free-forming cable bends of 10 times cable diameter. 90-degree bends are not permitted.

H. Provide splices, supports, and other fittings necessary for a complete, continuously grounded system.

I. Color shall be black matte finish.

J. Size and Configuration as follows unless otherwise noted.

1. Wire mesh: 2in x 4in (50 x 100 mm).
2. Cable Tray: 4in deep x 24in wide (105 x 600 mm).
K. Cable Tray fasteners, supports and accessories.

1. Fasteners to connect cable tray supports to the building structure as follows:
   a. Expansion anchors: carbon steel wedge or sleeve type.
   b. Toggle bolts: all-steel springhead type.
   c. Power-driven threaded studs: heat-treated steel, designed specifically for the intended service.

2. Cable drop-outs or waterfalls.
   a. Sizes to cable tray width for cable bundle distribution.
   b. Cable type compliant, meeting minimum bend radius.
   c. Same material and finish as cable tray.

3. Fittings shall be pre-manufactured tees, crosses, risers, elbows, and other fittings of same materials and finishes as cable tray.

4. Conduit to cable tray adaptors to be U clamp type of same material and finish as cable tray.

2.5 CABLE RUNWAYS

A. Provide cable runway/ladder tray in MDF/IDF closets, unless otherwise dictated by the FHITNM.

B. Provide certification with data substantiating that product complies with requirements of the contract documents. Furnish UL file number with product data as submitted.

2.6 EQUIPMENT CABINETS AND RACKS

A. Provide data racks, cabinets, etc. as shown on the contract drawings to meet the requirements of the surrounding environment, unless otherwise dictated by the FHITNM.

B. Open Frame Equipment Racks

1. 19-inch free standing two post equipment racks in IT closets, and four post equipment racks in datacenters and main distribution rooms unless otherwise specified by FHITNM.
   a. Double-sided with universal threaded mounting holes; 5/8 in – ½ in on front and rear
   b. 84 inch tall, 29 inch deep.
   c. 45 RU minimum.
   d. Universal numerical identifiers on rack rails.
   e. Include support rods, brackets, and pre-drilled holes for connecting/supporting ladder rack.
   f. Color shall be black.

C. Horizontal Wire Management Enclosures

1. 19-inch rack mounted
   a. Slotted, plastic finger duct with snap-on metal covers.
   b. CAT6 cable capacity equal to or greater than total number of fully loaded patch panel ports using 40% fill rate.
D. Vertical Wire Management Enclosures

1. 84-inch-tall rack mounted
   a. Mounted to support entire length of rack.
   b. Rigid metal cable manager with 1U spaced plastic cable finger guides.
   c. Rear and front mounted (double sided) cable management capability designed for Cat 6 and fiber installations based upon a fill rate of 35% to accommodate proper cable routing techniques.
   d. Quantity required.
      1) Provide two units the height of rack for each open frame data rack. Minimum 6” wide.
      2) Provide one unit only between side-by-side mounted racks. Minimum 12” wide.

2.7 CABLES

A. Manufacturers: Refer to Appendix A.

B. All horizontal cabling shall be Commscope Category 6, except wireless access points shall be Commscope Category 6A.

C. Unless specified otherwise in the drawings, specifications or other contract documents, telecommunications cables shall be as specified in this document.

D. All cabling shall comply with all national, state, and local code/standards. All copper cabling shall bear CMP, CMR and/or appropriate marking for the environment in which they are installed. All fiber optic cabling shall bear OFNP, OFNR and/or appropriate markings for the environment in which they are installed.

E. Pre-approved list of manufacturers and part number will be found in Appendix A of this document. Any alternates must be pre-approved by the FHITNM.

F. Horizontal Cables

1. Horizontal cables shall comply with all ANSI/TIA standards and all nations, state, and local codes. All terminations shall comply with the T568B wiring topology.

2. Horizontal cable runs shall be run from the telecommunications room to the end user, and must be continuous runs with no intermediate splices or cross-connects.

3. Cables are to be terminated on modular jacks at each location and terminated in patch panels for 19” equipment racks.

4. Unless otherwise specified or noted in the drawings or specifications, the contractor shall confirm the cable coloring with the FHITNM prior to installation.

G. Workstation Outlets

1. Modular jack colors will be dependent on the use of cable installed.
   a. Standard data drop – White/Ivory (Based on Electrical Plate Colors)
   b. IDF Jacks – Black
   c. Bio-Med – Orange – both sides of permanent link
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d. Wireless Access Points – Blue – both sides of the permanent link

e. Point to point cables – Yellow on each end of PTP cable.

f. All other color choices must be approved by the FHITNM.

2. Contractor to confirm mounting height for wall mounted arms/brackets with FHITNM prior to rough-in / installation.

3. Television backbox and related equipment mounting heights to be confirmed with FHITNM prior to rough-in / installation.

4. Unless otherwise specified or noted in the drawings or specifications, the contractor shall confirm the modular jack coloring with the FHITHM prior to installation.

H. Fiber Optic Cables

1. Fiber optic cables shall comply with all ANSI/TIA standards and all national, state, and local codes.

2. Commscope Armored fiber or Sumitomo Air Blown Fiber shall be used whenever possible and applicable. When armored fiber cannot be used, innerduct shall be used, but needs to have FHITNM approval.

3. Fiber optic runs must be continuous with no intermediate splices or cross-connects.

4. Unless otherwise indicated on contract drawings, a minimum of 24 strand single-mode fiber cable shall be run to each new telecommunications room. Any deviations from this shall be FHITNM approved on a project-by-project basis.

2.8 CROSS CONNECT HARDWARE

A. General

1. ¾” AC grade plywood backboards shall be installed with 2 coats of fire retardant paint on all walls of the telecommunications room as indicated in the contract drawings. The fire rating certification stamps on plywood shall not be painted over.

2. 19” x 84” equipment racks shall be used unless otherwise directed by the FHITNM. Securely bolt racks to the floor. Ground and bond to meet or exceed current ANSI/TIA, NEC and NFPA.

3. All horizontal cables to be routed to equipment racks and terminated on path panels as detailed on contract drawings and the latest ANSI/TIA specifications and industry standards. All related hardware, patch panels and equipment racks shall be furnished by the contractor and shall be compatible with the horizontal and riser cabling to ensure signal quality.

4. All cable terminations shall comply with the T568B wiring topology.

5. Cable support in telecommunications rooms shall be cable runway or “ladder rack” whenever applicable and/or appropriate. Cables shall not be suspended more than 12” vertically unsupported.

6. The Appendix A in this document provides the list of FHITNM approved manufacturers and part numbers. Any alternates must be pre-approved by the FHITNM.

B. Voice Cross-Connects

1. Voice cross-connects only apply to analog connections. All other types of service are VoIP.
2. Voice cross-connects require FHITNM direction on a project-by-project basis. FHITNM direction is also required for the type and combination of voice termination hardware (patch panels, 66-blocks or 110 blocks) on a project-by-project basis.

3. Any substitutions require pre-approval by the FHITNM.

4. Ground and bond to meet or exceed current ANSI/TIA standards, NEC and NFPA.

C. Data Cross-Connects

1. Ground and bond to meet or exceed current ANSI/TIA standards, NEC and NFPA.

2. Telecommunications rooms with more than two equipment racks may require 4”x4” fiber-runner raceway installed on the outside edge of all the ladder rack within the room and have corresponding waterfall drop offs at each rack.

3. Furnish and install patch panels and terminate horizontal cables in numeric sequential order on the patch panels with labels on both ends as specified in “Labeling and Documentation” section of this document.

Any variances to a “numeric sequential order” must be approved by the FHITNM.

4. Furnish and install modular fiber patch panels and terminate fiber optic cables with LC connectors, unless otherwise specified or noted on the contract drawings. Fiber should be terminated in numeric sequential order on the patch panels and labeled on both ends as specified by the FHITNM.

5. Data cable management deviations must be determined and approved by FHITNM.

2.9 BROADBAND TELEVISION DISTRIBUTION SYSTEM – Refer to Specification 274110 – Broadband Television Distribution System.


2.12 PUBLIC ADDRESS SYSTEM – Refer to Specification 275113 – Public Address Systems.


PART 3 - EXECUTION

3.1 GROUNDING AND BONDING INSTALLATION

A. All equipment, whether furnished by Division 27 or others, shall be grounded.

B. Provide building grounding, ground connection for telecommunications, and ground connection for communication/special system services including underground, aerial, and antenna delivery systems.
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C. Fusion welds are to be in strict accordance with supplier’s instructions.

D. Grounding cables shall not be buried directly in concrete, but in a conduit sleeve where cable passes through concrete.

E. All bonding conductors run inside the building shall be run within NEC sized metallic raceways with raceway grounding, bushing and bonding jumper to the enclosure or ground bus. Extend raceway to within 6 inches of exposed ground terminal bar installation. Raceway installations shall be in accordance with Division 26.

F. Each bonding conductor bus connection shall be terminated with individual non-reversible compression lug with ¼ inch minimum stainless steel hex head cap screws with stainless steel washers, lock washers, and nuts.

G. Grounds & Grounding electrode conductors shall not be installed in building structure unless it is concealed.

H. Grounding cabinets and equipment racks.
   1. Tighten equipment grounding connections for system connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.
   2. Ground equipment, conductor and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.

I. Refer to project specific Division 27 section for breakdown of installation specifics.

3.2 INSTALLATION OF CABLE TRAY SYSTEMS

A. Install cable tray for horizontal ceiling corridor runs and associated extensions to local telecommunications room as shown on contract drawings.

B. Cable tray shall be trapeze supported on both sides.
   1. Variations of tray support must be identified as an exception by the FHITNM.

C. Wire mesh cable tray fittings shall be pre-manufactured at the factory. 90-degree bends are not permitted. Place supports so that support span does not exceed manufacturer’s recommendations based on the load of the project plus 25 percent.

D. Install cable tray level and plumb according to manufacturer’s written instructions and referenced standards.

E. Tray sections must be secured together as manufacture specified to maintain grounding conductor rating.

F. Support cable tray independently to the building structural components.

G. Make changes in direction of cable tray with standard cable tray fittings. Field manufactured fittings will not be accepted. Maintain specified fitting radius.

H. Coordinate firestopping locations to align with cable tray installation pathway.
1. Install listed firestopping sleeves at wall or floor penetrations where cables penetrate fire and smoke barriers including walls, partitions, floors and ceilings per Division 26 firestopping specifications. Trays are not to extend through rated fire walls.

I. Install capped sleeves for future cables through fire stopped cable tray penetrations of fire/smoke barriers.

J. Coordinate and install cable trays with sufficient space to permit access for installing cables. Leave at least 6 inches clear above tray while not impeding upon ceiling heights. Any variance of the clearance from obstructions and the tray must be approved by the FHITNM.

K. Provide cable dropouts.
   1. To properly support cable distribution bundles exiting bottom or side of tray.
   2. To allow change in elevation of tray.
   3. To enter/exit sleeves at partition walls.
   4. At equipment racks and equipment boards.

3.3 INSTALLATION OF CABLE RUNWAY SYSTEMS

A. Install cable runway/ladder tray systems and components in accordance with equipment manufacturer’s written instructions, in compliance with Nation Electric Code, and with recognized industry practices, to ensure that the system complies with requirements and serves intended purposes.

B. Install ladder type cable runway, not basket, for supporting communications cabling in telecom rooms above data racks. Install vertical backbone runs between stacked telecom rooms to ensure cabling support to slots, sleeves penetrating floors, ceilings, and entrances.
   1. Install horizontal cable runway 8 foot 6 inches above finished floor, or 1 foot above equipment racks.
   2. Install vertical raceway 6 inches from wall, adjacent to the equipment racks, entrance, sleeves, etc. CPI 10506-706 Should be used.

C. Support cable runway independently from the building structural components.

3.4 INSTALLATION OF CABINETS AND RACKS

A. Install equipment in accordance with manufacturer’s written instructions.

B. Provide cabinets, and associated raceway/pathway installations including special wire management auxiliaries.
   1. Both Vertical and horizontal cord managers should be included during fill calculations to ensure both can accommodate the anticipated maximum density of cords.
   2. Maximum calculated fill of 25% should be taken into account (including service loop).
   3. Vertical managers should extend from the floor to the top of the racks.
      a. Quantity required
         1) Provide two units the height of rack for each open frame data rack. Minimum 10” wide.
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2) Provide one unit only between side-by-side mounted racks. Minimum 12” wide.

4. Horizontal managers should be installed to accommodate maximum calculated fill requirements and providing for a strategic growth factor of up to 100%. Cable management should be adequate to ensure that the cables can be neatly dressed and do not impair cooling, and that bend radius requirements are met.

C. Assemble and locate cabinets and racks per riser diagrams, as shown on drawings and approved submittal layout drawings.

1. Mount a minimum of 3 feet from back of rack to wall.

2. Secure to floor using 1/2-inch hardware minimum.

3. Install wall mounted cabinets 60 inches from the floor to top of unit.

D. Coordinate rack locations with telecom conduits, fire rated assemblies and sleeves entering telecom room.

E. Coordinate rack locations with cable tray entrance and cable runway installation.

F. Cabinets and racks are to be a minimum of 20 feet from electrical distribution panels greater than 480 volts. Locate racks to maximize the distance from sources of EMI such as transformers, power panels, fluorescent lighting, etc.

G. Label all racks and cabinets at top of rack with facility, telecommunications room designation/number, and rack designation as shown on drawings and approved by FHITNM.

3.5 INSTALLATION OF CABLES

A. All cable runs and routing shall comply with current ANSI/TIA-568, ANSI/TIA-569 and ANSI/TIA-1179 standards.

1. All horizontal cable runs shall have a maximum length of 90m (295 ft) and shall be installed as single continuous “home-run” pulls from patch panel to workstation outlet. No taps, splices, etc. shall be permitted. If cable runs are anticipated to exceed this length by installers, the FHITNM must be immediately notified for resolution.

2. Cables shall be dressed and terminated in accordance with the recommendations made in the current ANSI/TIA-568 standard, manufacturer’s recommendations and industry best practices. All terminations shall comply with the T568B wiring topology. The cable jacket shall not be removed for termination no further than 1/2” from the termination point.

3. It is the contractor’s responsibility to verify plenum rating requirements. Unless otherwise noted, all above ceiling space is to be considered return-air plenum space. All cabling in such spaces is to be installed as per NEC 809.154.

4. All cabling that has become abandoned is to be completely removed.

5. Cable support and routing
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a. Primary cable routing shall follow the logical structure of the building and follow hallways as much as possible. Cables and raceways should be routed parallel or perpendicular to the building structure. No diagonal runs shall be permitted unless otherwise noted in the contract drawings or by FHITNM's direction. At wall penetrations cables shall pass through pre-established sleeve openings and should enter these openings at 90 degree angles. Crossing corridors should be avoided, if possible.

b. Cable installations shall be in a neat manner and in such a manner that the cable will not be damaged by normal building use. Cables shall be supported by the building structure, but not attached to or laid on ductwork, mechanical systems, conduit, plumbing lines, fire suppression systems, environmental sensors, ceiling grid or ceiling grid wires. All cables are to be bundled using approved Velcro ties. Absolutely no vinyl, electrical tape or cable ties shall be used to bundle, secure or support any cables.

c. Cable tray, cable runway or j-hooks shall be used to support all cables.

d. Where j-hooks are to be used they should be attached to the existing building structure and framework at a maximum of 4ft intervals. J-hook spacing should be staggered to avoid harmonics.

e. Cables are to be bundled in bundles of 50 or less and separated and bundled in like groups by cable sheathing colors. All cables are to be bundled using Velcro ties, snug, but not deforming the cable geometry. Minimum bend radius and pulling tension requirements should always be adhered to as specified by the cable manufacturer and most recent version of ANSI/TIA-568.

f. Vertical riser cables shall be supported on vertical ladders, cable tray or channel using hook and loop fasteners or Velcro, and adequately supported for the type and length of cable.

g. Copper cables shall not be placed near sources of extreme heat (i.e. heating coils, radiators, boilers, etc.)

h. Cabling within telecommunications rooms shall be neatly placed and dressed in runways, cable trays or vertical and horizontal rack/cabinet cable managers. D-rings are to be used when trays, runways or managers are not specified.

6. The contractor will assure all new cabling is free of sharp bends, kinks, twists, cuts, tears, bulges or any other physical damage which may cause electrical or physical characteristic alterations to the cables. If any such damage is detected the contractor shall completely remove and replace all affected cables at no expense to the FHITNM.

7. Cables are not permitted to be painted at any time. If any cable is painted during a project, the contractor shall completely remove and replace all of the affected cables at no expense to the FHITNM.

8. Separation from EMI Sources:

a. Comply with BICSI TDMM and TIA-569-C for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.

b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).

3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).

2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).

3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

1) Electrical Equipment Rating Less Than 2 kVA: No requirement.

2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).

3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).

f. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

9. Coordination of all cubicle workstation outlets with the architectural furniture layouts and the FHITNM is the responsibility of the contractor. If needed the contractor shall furnish and install surface mounted raceways as required for modular furniture partition mounted workstation outlets.

10. All cables will have a minimum of a 3ft service loop. Wireless access point (WAP) and video surveillance (camera) locations shall have a minimum of a 20ft service loop. The additional length shall be coiled at 200% of their recommended minimum bend radius. The coil shall be Velcro-tied and tagged with the cable number.

11. The contractor shall provide a Hilti Speed Sleeve at locations where cables pass through walls. The contractor is responsible for all cutting, patching, and restoration to the original condition of walls, ceilings, floor, etc. Patching material must be approved by the FHITNM. Any patching done with non-approved materials shall be removed and replaced at the expense of the contractor.

12. The contractor is responsible for all firestopping sealant of openings between floor, through fire and smoke rated walls. These penetrations created cable pathway are the responsibility of the contractor. Sealing material and application shall be accomplished in compliance with the NFPA as well as local fire and building authorities. Only firestopping material approved by the FHITNM shall be used. Any non-approved materials shall be removed and replaced at the expense of the contractor.

13. All cabling penetrations through fire-rated wall and structures shall be “Hilti Speed sleeves”. All locations shall be labeled identifying the fire stopping material, UL listing and hour rating of the wall or floor.
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14. The contractor is responsible for all damages to any surfaces or work disrupted because of their work. All repairs, including painting, shall be included.

B. Wireless LAN System Installation

1. Wireless access points shall be provided by the FHITNM.
2. The contractor is to include installation of the access points at location shown on the contract drawings.
3. A 20ft service loop is to be provided by the contractor at each access point location.
4. Oberon enclosures will be used for all WAP installations. Tegular, non-regular and wall mount as dictated by the environment.
5. Each WAP locations will be served by 2 X Cat 6A cables.

3.6 TELECOMMUNICATIONS ROOMS

A. General

1. Main Distribution Frame (MDF)
   a. One MDF per facility is required in new construction.
   b. For existing facilities coordinate with FHITNM for changes or additions to the existing MDF.
   c. Size should be a minimum of 20’ x 28’ for new construction.
   d. MDF should be centrally located on the main level.

2. Demarcation Room (Demarc)
   a. One Demarc per facility is required for new construction.
   b. Size to be at least 10’ X 15’
   c. For existing facility renovation, coordination with FHITNM for changes or additions.
   d. This room is to be used for service provider entrance into the facility only.
   e. Demarc should be centrally located adjacent to the MDF.

3. Telecommunications Room (TR)
   a. Size should be at least 12’x16’ for Hospital new construction and negotiable for smaller projects (per proper planning meetings with network and telecom teams).
   b. Size for MOB (Medical Office Building) new construction should be at least 10’ x 12’
   c. Each TR will serve maximum areas of 20,000 square feet or less according to TIA/EIA standards.
   d. TR should be centrally located within the area it is serving, stacked with relation to other TRs above and/or below is preferred.

B. Construction Requirements

1. MDF
MDF shall be available for IS equipment installation four weeks prior to FHITNM occupancy of the facility. All construction must be complete, electricity available and the room safe from contamination from air systems or adjoining spaces.

Fire self-activating seal conduit should be used for penetrations through all firewalls and smoke walls. The preferred product is Hilti Speed Sleeve. This product will be installed by the cabling vendor. This can be modified as new products are available but must be approved by Froedtert Health IS department.

All walls shall have the 3/4” fire retardant plywood attached and painted with fire retardant paint with manufacturer’s rating seal exposed.

A minimum of 18” ladder runway around the perimeter of the room as well as directly over the racks(s).

The door shall be a minimum of 36” wide 80” high, without doorsill, hinged to open inward (into the MDF) and fitted to lock and a door sweep installed. This closet should also be card accessed.

Lighting shall be a minimum of 540lx (50ft candles) measured 1m (3ft) above the finished floor, mounted 2600-mm (8.5ft) minimum above the finished floor. Room lighting shall be LED.

Wall electrical outlets to be surfaced mounted. This will assist greatly when needing to extend power to accommodate growth and/or irregular heights of various vendor components. No dangling power cables, and overused single/quad outlets will be allowed.

An isolated grounding BUS bar (location and size to be determined based upon need) must be installed by the electrical contractor: Ground run back with #6 electrical wire to the XO and Neutral in a conduit with the phase conductors if a transformer is used or back to the Main Panel Disconnect if no transformer. Confirm requirements with current NEC. Please refer to Section 2.2 Sub D for bus bar size definitions.

Floors should be VCT tile. Walls and ceiling shall be painted to eliminate dust. Finishes shall be a light color to enhance lighting.

The flooring and painting must be completed before communication racks and cabling are installed.

Sprinkler heads shall not be placed directly over IT Equipment or racks, and shall be provided with wire cages to prevent accidental operation.

Fire suppression for the MDF shall be FM200. This system must be dedicated to the MDF.

No systems shall be permitted to pass through the MDF that do not serve the MDF: i.e., sprinkler systems, ductwork, electrical conduits, plumbing, etc.

MDF to have a “hot aisle/cold aisle” layout. HVAC design to be such that the cold aisle temperature remains within a 68-to-75-degree range with a humidity range of 30to 55 percent throughout the MDF. Thermostats should be in the cold aisles. The cooling system shall be independent of the building HVAC system.
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o. Provide (2) L6-30 outlets per rack at top of rack and at least (1) NEMA 5-20 duplex outlet at top of rack, each on separate circuits, with one (1) emergency power and one (1) on UPS or normal power. This power should be extended via conduit from above and attached to basket or ladder tray on the rear of racks. This installation will require field coordination with the IT installing the rack system. (Refer to IDF power detail below). The rack power system will need to be on backup power.

2. Demarc

a. Demarc shall be available for service provider and Froedtert Health IS equipment installation four weeks prior to FHITNM occupancy of the facility. All construction must be complete, electricity available and the room safe from contamination from air systems or adjoining spaces.

b. Fire self-activating sealed conduit should be used for penetrations through all firewalls and smoke walls. The preferred product is Hilti Speed Sleeve. This product will be installed by the cabling vendor. This can be modified as new products are available but must be approved by FHITNM.

c. A grounding BUS bar must be installed by the electrical contractor: 4 inch W, ¼ inch H, 12 inch L (CPI part number for reference = 10622-012). This ground must be connected to the Main Building Ground Source with 6 AWG copper wire or larger determined by length of conductor. The bar will be installed by the electrical contractor, 5’ up from the floor, and behind the network/telecommunication racks. Confirm requirements with current NEC and FHITNM.

d. Floors should be VCT tile. Walls and ceiling shall be painted to eliminate dust. Finishes shall be a light color to enhance lighting.

e. The door shall be a minimum of 36” wide 80” high, without doorsill, hinged to open inward (into the Demarc) and fitted to lock and a door sweep installed.

f. There are to be no ceilings in the Demarc.

g. Fire suppression for the Demarc shall be the building fire suppression.

h. Sprinkler heads shall not be placed directly over the equipment racks, and shall be provided with wire cages to prevent accidental operation.

i. All walls shall have the 3/4” fire retardant plywood attached and painted with fire retardant paint with manufacturer’s rating seal exposed.

j. No systems shall be permitted to pass through the Demarc that do not serve the Demarc: i.e., sprinkler systems, ductwork, electrical conduits, plumbing, etc.

k. Service provider conduits entering the Demarc from the site shall be a minimum of 4” and be placed in the corner of the room with a minimum 12” ladder rack (attached to plywood) leading up to cable tray.

3. TR (Telecommunications Room)

a. This closet shall be available for IS equipment installation at least four weeks prior to FHITNM occupancy of any space this room serves. All construction must be complete, electricity available and the room safe from contamination from air systems or adjoining spaces.
b. All painting, flooring, air conditioning, and construction provided services must be completed for this room at least two weeks before the ceiling grid is installed in the hallways, so the cabling installer can pull cable, lay it in the cable tray, and install the cable to the racks in the network closet.

c. Fire self-activating seal conduit should be used for penetrations through all firewalls and smoke walls. The preferred product is Hilti Speed Sleeve. This product will be installed by the cabling vendor. This can be modified as new products are available but must be approved by MHS IS department.

d. All walls shall have the 3/4” fire retardant plywood attached and painted with fire retardant paint with manufacturer’s rating seal exposed.

e. Any core holes should be a minimum of 4” and be placed in the corner of the room and behind the racks with a minimum 12” ladder rack (attached to plywood) leading up to cable tray.

f. A minimum of 12” basket tray around the perimeter of the room as well as directly over the racks(s).

g. Lighting shall be a minimum of 540lx (50ft candles) measured 1m (3ft) above the finished floor, mounted 2600-mm (8.5ft) minimum above the finished floor. Lighting shall be LED.

h. Wall electrical outlets to be surfaced mounted. This will assist greatly when needing to extend power to accommodate growth and/or irregular heights of various vendor components. Would like to get away from dangling power cables and overused single/quad outlets.

i. Provide (2) L6-30 outlets per rack at top of rack and at least (1) NEMA 5-20 duplex outlet at top of rack, each on separate circuits, with one (1) emergency power and one (1) on UPS or normal power. This power should be extended via conduit from above and attached to basket or ladder tray on the rear of racks. This installation will require field coordination with the IT installing the rack system. (Refer to IDF power detail below). The rack power system will need to be on backup power.

j. Wall mounted convenience duplex outlets should be placed at 6ft intervals on their own individual circuit and should be surface mounted.

k. A grounding BUS bar must be installed by the electrical contractor: 4 inch W, ¼ inch H, 12 inch L (CPI part number for reference = 10622-012). This ground must be connected to the Main Building Ground Source with 6AWG copper wire, or sized by length of conductor. The bar will be installed by the electrical contractor, 5’ up from the floor, and behind the network/telecommunication racks. Confirm requirements with current NEC.

l. There are to be no ceilings in the IDF closets.

m. The door shall be a minimum of 36” wide 80” high, without doorsill, hinged to open inward (into the IDF) and fitted to lock and a door sweep installed. This closet should also be card accessed.

n. Floors should be VCT tile. Walls and ceiling shall be painted to eliminate dust. Finishes shall be a light color to enhance lighting.

o. The flooring and painting must be completed before communication racks and cabling are installed.

p. Fire suppression for the TR shall be the building fire suppression.
Sprinkler heads shall not be placed directly over IT Equipment or racks and shall be provided with wire cages to prevent accidental operation.

No systems shall be permitted to pass through the TR that do not serve the TR: i.e., sprinkler systems, ductwork, electrical conduits, plumbing, etc.

HVAC requirements for TRs shall be ¾ ton of cooling per equipment rack within the TR. (example: three racks = 2 ¼ tons of cooling). Planning for eventual provisioning as required, of continuous HVAC (24 hours per day and 365 days per year) shall be included. A sufficient number of air changes should be provided to dissipate the heat from active devices. The temperature within the TR must stay within 68-to-78-degree range with a humidity range of 20 to 80 percent throughout the room.

4.1 IDENTIFICATION

A. General

1. All telecommunications system components, wiring, and cabling labeling must comply with TIA/EIA-606-B. These labels must meet the requirements of UL969 as outlined in the TIA Standard. All labeling shall be approved by the FHITNM before application of said labeling.

2. Machine generated, self-laminating labels must be used on all wire and cable identification. Absolutely no handwritten labels will be accepted.

3. All horizontal and backbone cables shall be labeled at each end. Additional labeling shall be required at intermediate locations such as pull boxes and conduit ends. Labels shall be within 6 in of the cable termination.

B. Each distribution frame shall have a permanently install label. The label shall be black letters on a white background with 3/8in letter height minimum, or equal approved by the FHITNM.

C. The contractor shall label all cross connects (110 or 66 blocks) with pre-printed color-coded designation strips as approved by the FHITNM.

D. Each patch panel shall be labeled. The label shall contain black letters on white background, with a minimum of 3/8in letter height, or equal as approved by the FHITNM. Patch panels shall be labeled numerically from the top of the rack working down.

E. Telecommunications outlet faceplates shall have permanently installed labels to coincide with the appropriate TR room name, patch panel and port number. The label shall contain black letters on white background, with a minimum of 1/8in letter height, or equal as approved by the FHITNM.

F. The contractor shall label fiber optic cable ends and patch panels as per FHITNM direction.

4.2 INSPECTION

A. The FHITNM and/or any authorized representatives shall have access to the construction site at all times for the purpose of inspecting equipment, material and installation; to obtain information regarding work progress and delivery; and for the purpose of installing telecommunications equipment.

4.3 TESTING

A. General
Froedtert Health Division 27 Telecommunication Standards

1. The contractor shall perform complete cable certification tests, including but not limited to: continuity checks on each cable, checking for opens and shorts between conductors, cable length and correct pair polarity.

2. The contractor shall provide the FHITNM 48 hour notice prior to the start of testing. The FHITNM will then have the option to observe any and/or all cable testing procedures.

3. The tests shall be performed after termination with connectors installed.

4. Cable certification readings shall be used to determine the acceptability of the installed cabling system. TIA/EIA-455, TIA/EIA-526 and ANSI/TIA-568-C, guidelines shall be used to determine acceptability.

5. Any outlet, cable or component not passing the tests shall be repaired or replaced at the expense of the contractor.

B. Copper testing

1. Visually inspect cable jacket.

2. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA/EIA-568-C.1.

3. Visually inspect cable placement, cable termination, and labeling of all components.

4. UTP Performance Tests:

   a. Test for each outlet. Perform the following tests according to TIA/EIA-568-C, and prepare test reports:

      1) Wire map.
      2) Length (physical vs. electrical, and length requirements).
      3) Insertion loss.
      4) Near-end crosstalk (NEXT) loss.
      5) Power sum near-end crosstalk (PSNEXT) loss.
      6) Equal-level far-end crosstalk (ELFEXT).
      7) Power sum equal-level far-end crosstalk (PSELFEXT).
      8) Return loss.
      9) Propagation delay.
     10) Delay skew.

   b. Test reports are to be submitted to the FHITNM in PDF format.

C. Coaxial Cable Tests:

1. Visually inspect cable placement, cable termination, and labeling of all components.

2. CATV outlets shall be tested with RF signal strength meter for 50-860 MHz. Signal at the outlet shall be 4-9dBmV, with 5cB max tilt.

3. Test results are to be submitted to the FHITNM in PDF format.
D. Fiber Optic Testing

1. All fiber optic testing shall conform to the TIA-455 and TIA-526 specifications. All fiber strands shall be tested using Tier 2 test requirements.

4.4 Submittals

A. Records and Drawings

1. Upon completion of the project, the contractor shall deliver marked prints showing the actual routing of cable runs, outlet locations, distribution frame layouts, punch down block locations, etc.

2. Wireless access point location on marked-up prints to contain MAC addresses, cable numbers and WAP ID. Confirm with FHITNM for termination sequence.

B. Cabling system Documentation

1. The contractor is to provide complete written system instruction manuals, which shall include, but not limited to, the following:
   a. First page: title of job, FHITNM, address, date of submittal and name of contractor
   b. Second page: Index
   c. First section: one copy of each accepted shop drawing, equipment catalog cutsheets and manufacturer’s instructions for all components and materials utilized in the telecommunications cabling system.
   d. Second section: one copy each of completed and accepted cable and component test reports.

C. The contractor shall provide copies of the original signed drawings by the FHITNM representative depicting TR layouts and acceptance of specifications.

APPENDIX A: APPROVED MATERIALS LIST

Cabling Systems Approved manufacturer: CommScope (all products subject to confirmation with project specific specifications)

- Typical telecommunications cable termination:
  - Category 6 cabling, blue, CS37R or CS37P, UN874043004/10
  - Cat6 jacks, MGS400series Black at Closet 70020667
  - Cat6 jacks, MGS400series White at standard data outlet 700206725
  - Cat6 jacks, MGS400series Orange for both ends of Biomed data outlet 700206683
  - Jack panel - Patch panels, 1U 48 port, 760105429
  - Patch cables, Uniprise cat6, blue, 1ft length, UNC6-BL-1F - IDF
  - Patch cables, Uniprise cat6 blue, 5ft length, UNC6-BL-5F - Workstation
  - M14LE Type flush mount faceplates 4 port white – 108168543
  - 4 port 1 gang stainless steel flush plate with labels - 760072207
  - M102SMB-262 surface mount box white - 107984056
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- **Wireless Access Point**
  - Category 6A cabling, blue, CS44R or CS44P, UN8744035114/10
  - Jack panel - Patch panels, 1U 48 port, 760105429; with blue jacks on each end of the permanent link.
  - Patch cables, Uniprise cat6A, blue, 1ft length, UNC10G-BL-1F
  - Patch cables, Uniprise cat6A blue, 3ft length, UNC10G-BL-3F
  - Oberon enclosure (type determined per project) 1047-COAP4800-T, 1047-COAP4800, 1011-00-WH, 1076-COAP4800
  - Cat6A jacks, MGS600 series Blue Jacks at Oberon side and closet sides. 760092452
  - M202SMB surface mount box white - 760057331

- **Fiber Optics**
  - Singlemode armored fiber, OS2, TeraSpeed, 24 core SM Armored Plenum 76027886
  - 1U - HD sliding style termination shelves – 760209940
  - 4U – UD fiber shelf - 270
  - LC style fuse-on SM connectors ends – 760117895
  - 12 port/24 core SM bulkhead adapter panel – 760216762
  - 3-meter LCLC SM duplex fiber Jumper CommScope FEXLCLC42-MXM003
  - 2-meter LCLC SM duplex fiber jumper CommScope FEXLCLC42-MXM002

- **Sumitomo Tube System Fiber Cabling**
  - Tube Cables
    - TC19TP2 – 19 Cell Plenum Tube Cable
    - TC12TP2 – 12 Cell Plenum Tube Cable
    - TC07TP2 – 7 Cell Plenum Tube Cable
    - TC04TP2 – 4 Cell Plenum Tube Cable
    - TC02TP2 – 2 Cell Plenum Tube Cable
  - Tube Couplers and Caps
    - DE08MC2 – 8mm Tube Couplers
    - DE08MA – 8mm Tube Plugs
  - TDU Distribution Panels
    - DE06MDU – 16x16 TDU Tube Distribution Unit
    - DE20IDU – 20x20 TDU Tube Distribution Unit
    - DE36IDU – 36x30 TDU Tube Distribution Unit
  - Heat Shrink Tube to TDU Couplers / Entry Seals
    - DECES3 – 2 Cell to 7 Cell Entry Seal
    - DECES4 – 19 Cell Entry Seal
  - Single-mode Fiber Optic Cable
    - FB12SXS – 12 Strand OS2 Fiber Optic Cable
    - FB24SX – 24 Strand OS2 Fiber Optic Cable
    - FB48SX – 48 Strand OS2 Fiber Optic Cable
  - Blowing Equipment
    - BE200RM – Blower Kit (Rental)
    - BERE02 – Pressure Regulator
    - BERE0CA – Compressed Air Cylinder Adaptor
    - Industrial Grade Inert Nitrogen N2 Dry Gas for Blowing Fiber

**Grounding and Bonding Approved manufacturer: (all products subject to confirmation with project specific specifications)**

- **Ground Rods:**
  - Erico Products
  - Knight Metalcraft
  - Nehring
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- **Molded fusion Welding Material**
  - Cadweld
  - Thermoweld
  - UltraWeld

- **Irreversible Compression Connectors**
  - Burndy Hyground Series
  - StructureGround
  - E-Z-Ground

- **Enclosure Equipment Grounding Kits**
  - Same Manufacture as box/cabinet

- **Grounding Busbar**
  - Chatsworth 40153-012(12") and/or Chatsworth 40153-024(24")

- **Building Entrance Terminals**
  - Porta Systems Corp or approved equal by CIRCA Enterprises, Inc
  - CommScope

- **Cabinet and Rack Grounding Provisions**
  - Copper B-Line
    - Paint piercing grounding washer kit, # RGW
    - Bonding screws for all equipment, # RGTBS
    - Equipment jumper kits (5 total for each rack), # RGEJ
    - Rack mounting Lug, #6 LUG
    - Electrostatic discharge port kit (include ESD wrists strap), # RGESD

**Wire Basket Cable Tray Approved Manufacturer:**
- B-Line Systems, Inc. FT4x24x10 or approved size. Coordinate with FHTNM.

**Cable Runway Approved Manufacturer:**
- Chatsworth Products, Inc.

**Quadra Rack 4-Post Frame**
- Chatsworth Products, Inc. part # 50120-703 (IDF’s & MDF)

19 inch Free Standing Equipment Rack
- Chatsworth Products, Inc. part # 55053-703 (IDF’s & MDF)

**Horizontal Wire Management Enclosure**
- Chatsworth Products, Inc. part # 35441-701

**Vertical Wire Management Enclosure**
- Chatsworth Products, Inc. G2 Series
  - 10in Chatsworth Evolution G2 Double Sided Vertical Manager # 35523-703
  - 12in Chatsworth Evolution G2 Double Sided Vertical Manager # 35524-703
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**Broadband Television Distribution System Components**

- Coaxial Cable – Quad Shield Plenum 2227V White RG6 CommScope 4112704/10
  Quad Shield PVC 5740R BKRL RG6 CommScope 8213304/10
- Faceplate
  - Leviton faceplate – white – 42080-1WS
  - F Connector Belden SNS # FSNS1P6QS
  - Ceiling mount pole from the monitor to the deck above. Peerless ceiling mount for 42” monitor; # PLCM-UN1-CP

**Audio-Visual System components**

- Coordinate with the Froedtert Health Systems prior to any substitution or replacement of components.
- Control Processor
  - Extron 60-1416-01
- Scaling Presentation Switcher
  - Extron IN1608 IPCP MA 70 (60-1238-13)
- HDMI Switchers with EDID Minder
  - Extron SW6 HDMI
- Contact Closure
  - Extron CCR 2BLB
- 80” LCD Flat Panel HDTV
  - Sharp LC-80LE661U
- LCD Monitor Wall Mount
  - Chief PAC525FBP2 or approved equal
- Mini PC
  - HP EliteDesk 800 G1 Desktop Mini business PC
- Speakers
  - Extron SF 26CT (60-1310-03)
- Blu-Ray Disc Player with built-in Wi-Fi
  - Sony BDP-BX370 or pre-approved equal
- 12V Power Supply
  - Extron PS 1210 C (70-775-01)
- Monitor 24”
  - ASUS VE248H
- Shielded Twisted Pair Cabling
  - Extron #STP201P
- HDMI Female to Female on 10” pigtail, one 3.5mm stereo mini Jack
  - Extron 70-1018-02
- Single-gang Wall Plate
  - Extron CPM101
- Digital HDMI 1.4a cable
  - Extron HDMI Pro Series

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**Sound Systems**
- Speakers
  - JBL 24CT
- AM/FM Tuner
  - Denon DRA-37
- Multi-CD Player
  - TEAC PD-D2620
- Speaker Cable
  - West Penn WP 292

**Public Address System**
- Manufacturer
  - Bogen
- Power Amplifier
  - Bogen GS150D
- Cone-type Loudspeaker
  - Bogen S86T725
- Flush Mount Ceiling Baffle
  - Bogen PG8W
- Speaker/Baffle Support Bridge
  - Bogen TB8
- Paging Speaker/Horn; Indoor
  - Bogen PA15TA
- Paging Speaker/Horn; Outdoor
  - Bogen PA15TA
- Jacketed twisted-pair untinned solid copper conductor cable
  - Belden 6300FE

**Door Entry Intercom System**
- Manufacturer (Basis of Design)
  - 2N Verso Intercom system
APPENDIX B: TYPICAL RACK LAYOUT

Typical IDF rack layout (exact equipment to be coordinated with the FHITNM per project)
SECTION 274110 - BROADBAND TELEVISION DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. General: Provide a broadband bi-directional Video Distribution System throughout the facility.
   1. The video distribution system shall be capable of distributing a broadband television signal to each location as described in these specifications and as shown on the Drawings.
   2. The video distribution system shall be extended and capable of distributing the existing broadband channels to the areas shown on the Drawings. All equipment shall be capable of 16 Hz bandwidth or greater.

B. Extent of RF Television Distribution System. RF Television Distribution system is comprised of, but not limited to, broadband distribution equipment for two-way communication over a single cable, broadband VHF and UHF amplifiers, channel combiners, signal processors, video monitors, multiplexers, portable return video carts, channel modulators, equipment racks, directional couplers/tapoffs, coaxial cable connectors, video signal cabling, wall plates, line terminators, splitters, taps and accessories. System is based on a trunk/bus topology utilizing the equipment, components and cabling as listed in these documents and shown on the drawings. A trunk cable shall be routed from the Building Tap and extending through each corridor.
   1. At minimum, an individual trunk cable shall be installed to each corridor of each floor where televisions re shown on the Drawing.
   2. Four-port taps will be utilized to connect trunk cabling into drop cabling being extended to each room.
      a. An individual cable drop shall be terminated in each room extending from the tap location in the corridor.
   3. Television monitors and wall brackets shall be installed in coordination with electrical and General Contractor’s Trades.
   4. Individual system specific cabling for extending audio/video and LAN from specified television or monitor are included in this scope of work.

D. System is based on a star topology utilizing the equipment, components and cabling as listed in these documents and shown on the drawings.
   1. An existing main CATV rack shall receive the incoming distribution signal, and amplifies that signal. The contractor shall extend the CATV via Fiber Optic cable signal to the existing MDF and connect the Blonder Tongue Amplifier.
   2. From existing MDF a RG11 cable shall be home run to each IDF.
   3. From IDF a RG6 cable shall be home run to each TV location.
   4. Contractor shall purchase and install LCD TVs and Mounts.

E. Refer to applicable Division 26 Sections for raceways, electrical boxes, and fittings, and wiring/cabling, required in conjunction with installation of RF Television Distribution System.

F. Requirements specified in the following Division 26 sections apply to this Section.
   1. Section "Basic Division 26 Requirements."
2. Section "Raceways."
3. Section "Conduit Rough-In Systems."

G. Requirements specified in the following Division 27 sections apply to this Section.
   1. Section "Basic Division 27 Requirements."

1.2 SUBMITTALS
   A. Submit the following in accordance with Conditions of Contract, Division 01 Specification Sections and Division 27 Section "Basic Division 27 Requirements."

1.3 ACTION SUBMITTALS
   A. Shop Drawings: Submit six (6) complete sets of shop drawings including:
      1. Equipment list.
      2. Manufacturer's product data for each type of product specified.
      3. Submit scaled diagrams indicating head end equipment layout and dimensions. Include layout of equipment in relation to room size and other existing and new system equipment in that room. Include rack equipment layout.
         a. Indicate connections to equipment supplied by others.
      4. Submit scaled system layout drawings using architectural floor plans for RF television distribution system equipment indicating cable types, amplifiers, electrical connections, taps, etc., as designed for this project.
         a. Include tap values, db levels and other important system configuration values.
         b. Include lengths of all trunk cables, feeder cables, and horizontal cables.
         c. Provide building room numbers and diagrams specific to this project.
         d. Differentiate between portions of equipment that are factory/vendor assembled and that which are field-installed.
      5. Wiring Diagrams detailing wiring for power, signal, and control differentiating clearly between manufacturer-installed wiring and field-installed wiring. Identify terminal numbers and wiring color codes to facilitate installation, operation, and maintenance.

1.4 INFORMATIONAL SUBMITTALS
   A. Field Testing Data.

1.5 CLOSEOUT SUBMITTALS
   A. Record Documents:
      1. Warranty and service agreement.

1.6 QUALITY ASSURANCE
   A. Manufacturer's Qualifications:
      1. Firms regularly engaged in manufacture of professional quality video systems, components and accessories, of types, capacities and characteristics required, who products have been in satisfactory use in similar service for not less than two (2) years.
B. Supplier's Qualifications:
1. Engage an experienced product supplier who is a factory-authorized sales and service representative regularly engaged in the design and installation of such systems to oversee the installation, trouble-shoot and make final connections at headend equipment.
2. Supplier shall have represented the product and components being installed for a minimum of two (2) years.

C. Installer Qualifications:
1. Firms with at least five (5) years of successful installation experience with projects installing professional video systems equipment similar to that required for this project.
2. Refer to Division 01 Section "Definitions and Standards" for definition of experienced Installer. Upon request submit evidence of such qualifications to the Architect/Engineer.

D. Electrical Component Standard: Provide work complying with applicable requirements of NFPA 70 "National Electrical Code."

E. Codes and Standards:
1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC 800-Series articles as applicable to installation, and construction of television equipment and signal distribution systems.
2. NFPA Compliance: Comply with applicable requirements of NFPA 78, "Lightning Protection Code," pertaining to television and antenna systems.
3. UL Compliance: Comply with applicable requirements of UL Standards 486A. Provide television systems and components which are UL-listed and labeled.
4. NEMA/ICEA Compliance: Comply with requirements of Stds Pub/No. WC 41, "Coaxial Communication Cable," pertaining to coaxial cable.
5. EIA Compliance: Comply with applicable requirements of Electronic Industries Association Standards RS-170, 222, 232, 312, 330, 403, 412, 420, 439, and 455 pertaining to television equipment and accessories.
6. NESC Compliance: Comply with National Electrical Safety Code requirements pertaining to materials and installation of antenna supporting structures for MATV systems.
7. FCC Compliance: Comply with Subpart J of PART 15, FCC Rules pertaining to computing devices including Class A, Class B, personal and peripheral types. Provide equipment which complies with technical standards for both radiated and power line conducted interference.

1.7 DELIVERY, STORAGE, AND HANDLING
A. Deliver TV system components properly packaged in factory-fabricated type containers. Store TV components in original cartons and in clean dry space; protect from weather and construction traffic. Dispose of all packaging materials and include the cost of packaging material disposal as part of the base bid.
B. Handle TV equipment and components carefully to avoid breakages, impacts, denting and scoring finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer.
1.8 SEQUENCING AND SCHEDULING

A. Coordinate with other work, including electrical wiring work, as necessary to interface installation of this system with other work.

B. Sequence TV system installation work with other work to minimize possibility of damage and soiling system during remainder of construction period.

PART 2 - PRODUCTS

2.1 RF TELEVISION DISTRIBUTION SYSTEM

A. General: Provide RF Distribution System equipment and installation at each building as listed and as shown on the drawings. Except as otherwise indicated, provide manufacturer's standard system components as indicated by published product information, designed and constructed as recommended by manufacturer. Provide RF Television Distribution equipment with the following functional and construction features.

B. Head End Equipment:

1. Broadband Indoor Distribution Amplifiers: Professional quality, broadband, 2-way capable, indoor hybrid distribution amplifier. 75 dB or 50 dB operational gain with built-in gain control. 1000 MHz frequency range.
   b. Provide and install the necessary BIDA 550-50 to deliver signal to TV.

2. Twelve Port Head end Tap(s): Provide quantity as required to connect the cables from the OC-12D combiners to the BIDA 550-50 distribution amplifier.

3. Diplexers and Power Supplies, Terminator “F” 75Ω, 10-2150 MHz, DC Blocking: Blonder Tongue LTF-2150

4. Fixed Attenuator Type “F”, Male – Female, Value 3: Blonder Tongue FAM-3

C. Infrastructure:

1. Multi-Port Indoor Splitters: Provide diecast 1000 MHz sixteen (16) - port splitters as required. The splitters shall have the built in capability of supporting a bi-directional broadband RF Distribution System. The splitter shall have built in mounting tabs and grounding block. The splitters shall have RF shielding and have in-line feed through capability. Furnish and install line terminators on all unused connectors and on all splitters.
   a. Blonder Tongue #SDS-16 (for all splitters from high to low outlet) or approved equal by Toner.
   b. Indoor Splitter Blonder Tongue - SCVS-4
   c. Environmental Sealed Connector – Belden SNS11AS
   d. Snap-N-Seal Environmentally Sealed F Male Connectors – Belden SNS1P6QS

2. Coaxial Cable: Cable from patch panels to wall outlets (horizontal cable) shall be RG6/U (Series 6) type, 5 to 1000 MHz, flexible coaxial cable; 75-ohm characteristic impedance; with single 18-gauge solid copper covered steel inner conductor; QuadShield; Aluminum Foil; 60% AL Braid, AL Foil, 40% AL Braid. Foam FEP Insulation and flexible plenum jacket. Quad Shield Plenum 2227V White RG6, Manufacturer – CommScope 4112704/10 WHRL RG6 QD 1000. Quad Shield PVC 5740R BKRL RG6 CommScope 8213304/10.
3. Coaxial Cable: Cable headend equipment, coaxial backbone cabling to termination closets (backbone cable) and horizontal runs exceeding 200 feet shall be RG11/U (Series 11) type, 5 to 1000 MHz, flexible coaxial cable; 75-ohm characteristic impedance; with single 14-gage solid copper covered steel inner conductor; QuadShield; Aluminum Foil, 60% AL Braid, AL Foil, 40% AL Braid. Foam FEP Insulation and flexible plenum jacket. Manufacturer – Commscope #2287V WTRL RG11 QD 1000.
   a. Provide connector or taps as required to reduce cabling at extended runs.
4. Coaxial Cable Connectors: Provide radio frequency, 1 Piece construction, compression, Type F cable connectors for RG6/U and RG11/U flexible coaxial video cable, where required.
5. Fiber Optic Cable: Armored Systimax, Riser Rated, and multimode OM3 part no. 760127183. 12 strands.

2.2 PROGRAM SOURCES
A. CATV Signal Input:
   1. Locate the Incoming Cable Television (CATV) Company signal and re-route it to the Video Distribution System Headend for re-distribution throughout the network. Provide amplification of signal as indicated or as required in these specifications.

2.3 TV LOCATION EQUIPMENT
A. Patch Cords:
   1. Provide one (1) RG-6 coaxial patch cord for each wall outlet:
      a. 4-foot, F-connector to F-connector factory assembled patch cord.

2.4 RACEWAYS, AND ELECTRICAL BOXES, AND FITTINGS
A. General: Provide conduit rough-in systems, raceways, and electrical boxes and fittings complying Division 26 Sections and other applicable sections for:
   1. Electrical Metallic Tubing (EMT).
   2. EMT Fittings.
   3. Interior Outlet Boxes.
   5. Bushings, Knockout Closures and Locknuts.
B. Cabling Supports:
   1. J-Hooks:
      a. Metallic J-hook bracket (1-1/2: wide) with cable retainer or Velcro strap, capable of being ceiling or support rod mounted.
         1) Provide manufacturer recommended fasteners as required.
      b. Acceptable Manufacturers/Series:
         1) Caddy Cat. 32 Series.
         2) B-Line BCH32 Series.
         3) Or Approved Equivalent.
C. Conduit Sleeves:
   1. Rigid Metallic Conduit Sleeves:
      a. 2-inch or 4-inch sleeves extending 4-6" on either side of firewall, partition or floor.
      b. Size for EIA/TIA 569, provide multiple sleeves as required.
      c. Firestop per Division 26.

2.5 CONNECTORS
   A. Contractor shall coordinate with the low voltage contractor for location of faceplate and manufacturer.
      1. Leviton Faceplate - White - 42080-1WS
      2. F Connector Belden SNS # FSNS1P6QS.

2.6 TELEVISIONS, MONITORS AND MOUNTS
   A. Contractor shall consult with owner's IT department prior to purchase of televisions, monitors and mounts as defined in the IT project product specification.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine areas and conditions under which television systems are to be installed, and notify Architect/Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.2 CABLING INSTALLATION REQUIREMENTS
   A. All cabling shall be fully concealed in the facility. All cabling shall be run in conduit or installed above accessible ceilings. Surface raceway allowed only where specifically shown on Drawings or approved by Engineer.
   B. Cabling may be installed "Open" in accessible ceiling spaces or crawlspaces.
      1. Cabling shall be supported 4-feet on center using J-hooks mounted on corridor walls.
         a. Install RF distribution cabling in separate pathways than other structured cabling system.
         b. Utilize metal mounting hardware in ceiling spaces.
      2. Cabling shall not be supported from conduits, piping, ductwork, etc. Cabling shall not lie directly on ceiling or be supported by ceiling tie-wires.
      3. Cabling shall be loosely cinched with cable ties at each mounting location. Cable ties shall not be overtightened.
   C. All open cabling penetrating walls or through floors shall be installed through rigid metallic conduit sleeves extending 2-3 inches on either side. Size sleeve as required to install cabling. Provide multiple sleeves as required. Provide bushings on all sleeves. Patch around sleeve as required. Provide firestopping in sleeve according to ASTM E814.
D. All cabling shall be installed parallel and perpendicular to building lines. Cabling bundles shall be installed level, taught and tight to building steel. Provide caution during installation so as to not stress, provide excessive tension on the cable or exceed manufacturers bend radius requirements.

E. Any cable jacket that is cut or scored during installation shall not be acceptable and shall be replaced in its entirety.

F. Cabling shall be routed in rigid metallic conduit to backbox (located at required height) concealed in new wall construction. Maximum of 40% fill in conduit.

G. Install cabling in pathways/raceways without exceeding NEC maximum fill for that raceway type.

H. Avoid sources of electromagnetic interface (EMI) for all video/control equipment and cables.
   1. Maintain 5" minimum from fluorescent lighting (ballast).
   2. Maintain 4’ minimum from all transformers.
   3. Maintain 1’ minimum from electrical power cabling.
   4. Distances may be shortened if sufficient EMI isolation is provided and prior approval is given by Engineer.

3.3 INSTALLATION OF RF TELEVISION SYSTEMS

A. Install television systems and components in accordance with equipment manufacturer's written instructions, in compliance with National Electrical Code, and with recognized industry practices, to ensure that television system complies with requirements and serves intended purposes.

B. Install television equipment properly to avoid causing mechanical stresses, twisting or misalignment of equipment being exerted by clamps, supports, and cabling.

C. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B, and the National Electrical Code.

D. Homerun TV cable from rack mounted RF distribution backboard within telecommunications room to each wall outlet as shown on the drawings.

E. Wall mount all splitters at video distribution amplifier at telecommunications room.

F. Provide branch circuit and power connection to video equipment racks and amplifiers as required. Indicate additional power requirements on wiring diagrams at submittal stage for approval by Engineer.

G. Remove all dirt, dust and construction debris from all system equipment. Touch-up scratched and marred surfaces to match original finishes to the satisfaction of the Owner/Engineer.

3.4 GROUNDING

A. Provide equipment grounding connections for video system. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.
B. Ground equipment, conductor, and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record and report ground resistance.

3.5 FIELD QUALITY CONTROL
A. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the pretesting, testing, and adjustment of the system.
B. Before final acceptance of the system, manufacturer-supplier of system shall, in presence of Owner's representative, test each and every component and device in the system. Test shall be documented with signed copy submitted to Owner and Architect/Engineer.
C. The system shall be physically inspected by the Owner's representative and the Architect/Engineer to assure that all equipment is installed in a neat and workmanlike manner as called for in the plans and specifications.

3.6 SYSTEM TESTING, ADJUSTMENTS, AND CLEANING
A. Upon completion of the system installation, and after circuitry has been energized with the normal power source, the manufacturer/supplier shall test the system to verify the following:
   1. All components are operational and functioning properly to the system designs intent.
   2. Perform all necessary adjustments and balancing of all signal and amplifier level controls including slope to insure proper operation.
   3. The complete system is free from grounds, open and shorts except for made grounds required by the system installation.
   4. Video output signal strength is between +6dBmV and +10 dBmV at all outlets for channel 2 approximately 55 MHz and channel 135 approximately 859 MHz (handled by division 26).
   5. Correct all of the above and retest to demonstrate compliance where required by Engineer.
   6. All testing shall be documented. Provide a signed copy to the Owner/Engineer verifying the system is complete, and fully functional.
B. Video Testing:
   1. Test every television outlet for signal level, clear picture and remote origination/control (as applicable).
      a. Tune for available channels.
      b. At each outlet, select each channel and view picture with television. Observe all active channels. Verify picture is clear with no visual presence of interference of any kind and no audible variance in volume level between channels.
      c. At each outlet, perform remote origination/control. Using television placed on any outlet, view remote origination. Verify picture is clear with no visual presence of interference of any kind and no audible variance in volume level between channels.
      d. Perform tests utilizing signal level meter to determine valves and record.
C. The manufacturer/supplier shall set all field adjustable components to optimize the system. Balance all signals, adjust and verify input voltages, current settings and frequency settings. Adjust gain and slope so signal shall be flat as possible across bandwidth.

3.7 TRAINING
A. Provide on-site training on the use of and operational aspects of the system to the Owner's selected personnel.
   1. Provide a minimum of 16 hours of training to selected personnel for the adjustment, troubleshooting, replacement of components and preventative maintenance of the system.
   2. Schedule training with Owner through Architect with at least seven (7) days advance notice.
B. Occupancy Adjustments: When requested by the Architect within one (1) year of date of Substantial Completion, provide on-site assistance in adjusting sound levels, resetting matching transformer taps, and adjusting controls to suit actual occupied conditions. Provide up to three (3) visits to the site for this purpose.

3.8 OPERATION AND MAINTENANCE MANUALS
A. Equipment Manuals:
   1. Approved copy of system submittal.
   2. Provide a complete set of equipment cut sheets, parts list, including maintenance criteria, "trouble-shooting" guide, distributor information and service information for all equipment provided.
   3. Provide a complete set of instruction manuals; including complete written programming instructions, programming documentation and system set-up documentation.
   4. Provide all test results performed. Include manufacturer's certifications that installed system complies with specification requirements.
B. Equipment Drawings:
   1. Contractor shall provide a revised set of system wiring diagrams upon the completion of the installation for subsequent testing of the system to show actual cable routing, connections with other systems cable lengths values of all equipment as installed and actual signal values as tested.
   2. Utilize architectural floor plans for system layout.

3.9 CLEANING AND PROTECTION
A. Prior to final acceptance, clean system components and protect from damage and deterioration.

END OF SECTION 274110
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SECTION 274111 – INTEGRATED AUDIO VISUAL SYSTEMS FOR CONFERENCE ROOMS

PART 1 - GENERAL

1.1 SUMMARY

A. New Audio Visual systems for use in Rounding Room to display.

1. Include comprehensive A/V systems consisting of modern solid state type equipment providing the following functionality:
   a. Audio/Video integration with media control of LCD and inputs.
   b. Flexibility to accommodate various uses of the room and various presentation types.

2. Be responsible for interfacing the systems with each required sub-system. Continually employ interfacing methods that are approved by the original equipment manufacturer and industry best practices. At a minimum, the acceptable interfacing method requires not only a physical and mechanical connection; but also a matching of signal, voltage, and processing levels, with regard to signal quality and impedance.

B. This Section includes requirements for A/V system components including, but not limited to, the following:

   1. A/V Sources; PC and network.
   2. A/V Switcher.
   3. Media Controllers.
   5. Equipment Cabling.
   6. LCD Flat Pane.

C. Products Installed but Furnished by the Owner or Products furnished and not installed.

D. Requirements specified in the following Divisions and sections apply to this section:

   1. Division 07 Section "Penetration Firestopping."
   2. Division 09 Section "Painting."

E. Requirements of Division 20 Section "Common Work Results, Division 21 through 28" apply to this Section.

F. Requirements specified in the following Division 26 sections apply to this Section.

   1. Section "Basic Division 26 Requirements."
   2. Section "Raceways."
   3. Section "Sleeves and Sleeve Seals."
   4. Section "Hangers and Supports."
   5. Section "Electrical Identification."
   6. Section "Grounding and Bonding."
   7. Section "Conduit Rough-In Systems."

G. Requirements specified in the following Division 27 sections apply to this Section.

   1. Section "Basic Division 27 Requirements."
   2. Section "Cable Runway."
   3. Section "Structured Telecommunications Cabling System."
   4. Section "Grounding and Bonding for Communications Systems."
1.2 PRICE AND PAYMENT PROCEDURES
   A. Allowances – Refer to Division 01, General Requirements for allowance information.
   B. Unit Prices – Refer to Division 01, General Requirements for unit price information.

1.3 REFERENCES
   A. Abbreviations and Acronyms:
      1. RCDD – Registered Communications Distribution Designer.
      2. TR – Telecom Room.
      3. CTS – Certified Technology Specialist.
      4. SEI / ASCE.
      6. AHJ - Authority Having Jurisdiction.
      8. AWG - American Wire Gauge.
     10. BDF - Building Distribution Facility; space within a building that is the nexus of LAN distribution for that particular building.
     11. Broadband - Wide bandwidth equipment or systems that can carry signals occupying in the frequency range of 54 to 1002 MHz.
     12. CAT 6 - Category 6 performance as defined by ANSI/TIA/EIA-568-B.2-1.
     13. CATV - Community Antenna Television.
     14. DC - Data Center.
     15. EIA - Electronics Industry Alliance.
     16. ELFEXT - Equal Level far End Cross Talk.
     17. ER - Equipment Room.
     18. EOR - Engineer of Record.
     19. FOTP - Fiber Optic Test Procedure.
     20. ILEC/LEC - Incumbent Local Exchange Carrier.
     22. ISP - Inside Plant; cable and equipment within a building.
     23. IT - Information Technology.
     25. LOMMF - Laser Optimized Multimode Fiber.
     26. LV - Low Voltage Room, Intermediate Distribution Facility; station and backbone cable concentration point on a particular floor for specific use on that same floor.
     27. MDF - Main Distribution Frame.
     28. MATV - Master Antenna Television.
     29. Main Low Voltage Room - Main Distribution Facility; space within a building that is the main point of LAN distribution for that building or to other buildings.
     30. MMF - Multimode Fiber.
     31. MPOE - Minimum Point of Entry; main entry point for all incoming building circuits, also serves as the primary demarcation point.
     32. MHz – Megahertz.
     33. NEXT - Near End Cross Talk.
     34. NECA - National Electrical Contractors Association.
     35. NEMA - National Electrical Manufacturers Association.
     36. OSP - Outside Plant; cable and equipment exterior to a building.
     37. OTDR - Optical Time Domain Reflectometer.
     38. PSELFEXT - Power Sum Equal Level far End Cross Talk.
39. PSNEXT - Power Sum Near End Cross Talk.
40. RCDD - Registered Communications Distribution Designer.
41. RF - Radio Frequency.
42. SMF - Single-Mode Fiber.
43. ScTP - Screened Twisted Pair.
44. SCS - Structured Cabling System.
47. Technology Outlet - Voice/data/video/other interface outlet located at workstation.
48. Telecom Spaces - Include all areas where cable or equipment will be placed, including IT resources, Engineering resources and user stations.
49. TIA - Telecommunications Industry Association.
50. TSER - Telecommunications Service Entry Room; Houses MPOE, above.
51. TDR - Time Domain Reflectometer.
52. TGB - Telecommunications Ground Bus Bar.
53. TMGB - Telecommunications Main Ground Bus Bar.
54. UTP - Unshielded Twisted Pair copper network and/or low voltage signal cable.
55. UL - Underwriters Laboratory.
56. UNO - Unless Noted Otherwise.
57. UPS - Uninterruptible Power Supply.
58. WAP - Wireless Access Point.

B. Definitions:

1. In addition to those Definitions listed in Division 01, the following list of terms shall be defined as follows:
   a. Connect - To install required patch cords, equipment cords, cross-connect wire, etc. to complete an electrical or optical circuit.
   b. Cabling - A combination of cables, wire, cords, and connecting hardware e.g., cables, conductor terminations, connectors, outlets, patch panels, blocks, and labeling.
   c. Identifier - A unique code assigned to an element of the telecommunications infrastructure that links it to its corresponding record.
   d. Open Cabling - Cabling run horizontally within a pathway supported by cable tray, J-hooks, D-hooks, etc. that is installed above an accessible ceiling. This installed cabling is considered concealed.
   e. Exposed Cabling - Cabling that is not concealed by an accessible pathway, conduit, etc. Cabling installed open below an exposed structure.
   f. Concealed Cabling.
   g. Pathway - Routing of cabling from work area outlet box to telecommunications room. Pathways may consist of conduit, conduit stub, conduit sleeve(s), cable tray, J-Hooks, etc.
   h. Telecom Cabling/Datacom Cabling – Low voltage extended frequency signal and communications cabling. Category 5e, 5E, 6, augmented 6 and fiber optic cabling.
   i. System Cabling – Low voltage signal and control cabling. System cabling is designated by the manufacturer for a particular system in each specification section.

C. Standards:

1. If this document and any of the documents listed herein are in conflict, then the more stringent requirement shall apply. All documents listed are believed to be the most current releases of the documents; this Division is responsible to determine and adhere to the most recent release when developing the proposal for installation.
b. ANSI/TIA/EIA 568-B.2-10, Transmission Performance Specification for 4-Pair 100 Ω Augmented Category 6 Cabling.

2. If a conflict exists between applicable documents, then the order in the list above shall dictate the order of precedence in resolving conflicts. This order of precedence shall be maintained unless a lesser order document has been adopted as code by a local, state or federal entity, and is therefore enforceable as law by a local, state or federal inspection agency.
1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Coordinate with other work, including electrical wiring work, cabinet and rack placement, casework / millwork and structured telecommunications cabling, as necessary to properly interface installation of this system with other work.
2. Coordinate all work with Division 26 for proper pathways and rough-in requirements; including but not limited to, size and bend radius.

B. Pre-Installation Meetings:
1. Meet with Owner for detailed system design and configuration review. Meeting to explain features, functionality and operability of system. Provide four 4-hour sessions.

C. Sequencing:
1. Sequence system installation work with other work to minimize possibility of damage and soiling system during remainder of construction period.

1.5 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections, and Division 27 Section "Basic Division 27 Requirements."

B. Submittals shall be provided based on specification number and be inclusive of the equipment within that section. Equipment submitted from multiple sections under a single cover, will not be reviewed.
1. Provide six (6) copies of all submittal information for review.
2. Provide electronic copy of all submittal information in PDF Format/Microsoft Word/Excel Format.

1.6 ACTION SUBMITTALS

A. Product Data: Submit for each type of product specified.
1. Provide manufacturer’s literature to include all information necessary to confirm that the proposed system is in complete compliance with the Specifications.
2. Provide all information in a single, complete bound submission.
3. Table of Contents identifying equipment lists with numbered pages corresponding to equipment/device locations within submittal for quick reference.
4. System Scope of Work narrative including Owner meetings, Owner reviews, programming approval, milestones, and testing.
5. Equipment Information:
   a. All equipment shall be specific to this section only unless required for integration.
      1) Manufacturer’s specifications and descriptive literature.
      2) Manufacturer’s recommended installation procedures.
      3) Equipment/device quantities.
      4) Equipment/device product information sheets with submission designated, installation information, color/finish options, etc.
      5) Program information sheets.
      6) Coordination requirements with all trades.
      7) Program layout diagrams, riser diagrams, wiring diagrams, rack elevations, seismic requirements, etc. Utilize Architectural, Electrical, and Communication symbology to be consistent with Owner's standards.
8) Deviations from specifications, if any, highlighted with specific explanation and identification requiring Architect/Engineer specific approval.
9) Manufacturer required information for base and extended warranties including submission requirements and timeframes.
10) Estimated equipment heat loads and power requirements. List and tabulate equipment specifically required in Telecommunications Rooms and Equipment Rooms.
11) Submit qualifications based on quality assurance requirements for manufacturer, supplier, installer, trainer, etc.
12) Provide secondary submittal for systems requiring programming and Owner input, review, and approval after Programming meeting, sequence of operations review, etc. Provide all information in spreadsheet format in electronic and hardcopy.
13) Training outline.
14) Sample test reports.

b. Provide a list with references of at least three (3) installations of equivalent or larger systems installed within the last two (2) years

1) Provide Facility location and name.
2) Owner’s or User’s name, address, and telephone (including fax) numbers.
3) Date of Project Start and Date of Final Acceptance by Owner.
4) System Project Number.
5) Brief (three paragraphs minimum) description of each system’s function, operation, and installation.

c. Provide certification with data substantiating that products comply with requirements of the Contract Documents. Furnish UL File number with product data as submitted.

B. Certification Letter: Provide certification letter in lieu of submittal. Refer to Division 01 requirements for procedure.

C. Shop Drawings (Submit for each):

1. Layout Drawings:

a. Submit scaled system layout drawings using architectural floor plans indicating head end equipment layout and dimensions. Include layout of equipment in relation to room size and other existing and new system equipment in that room. Include equipment layout and rack elevations.

1) Indicate connections to equipment supplied by others.

b. Submit scaled system layout drawings using architectural floor plans for system equipment indicating cable types, amplifiers, electrical connections, taps, etc., as designed for this project.

1) Include tap values, db levels and other important system configuration values.
2) Include lengths of all trunk cables, feeder cables, and horizontal cables.
3) Provide building room numbers and diagrams specific to this project.
4) All panels, plates and designation strips, including details relating to terminology, engraving, finish and color.
5) Detailed wiring for connectivity of other interfaces. Differentiate clearly intersystem connections.
6) Wiring Diagrams detailing wiring for power, signal, and control differentiating clearly between manufacturer-installed wiring and field-installed wiring. Identify terminal numbers and wiring color codes to facilitate installation, operation, and maintenance.

7) Remote control panel design (to include "live" interactive electronics format).

8) All equipment racks, cabinets, consoles, tables, carts, support bases and shelves.

9) Schematic drawings (A/V and Control Signal flows).

10) All non-factory equipment modifications.

11) Front mechanical drawings of each equipment rack.

12) System functional block drawings, including those for audio and video subsystems.

13) Cable labeling plan.

14) Grounding: Identify grounding requirements and connections to Telecommunications Grounding Busbar.

15) Differentiate between portions of equipment that are factory/vendor assembled and that which are field-installed.

2. Software and Schedules:
   a. Programming:

3. Factory Quality Control Test Reports:
   a. Warranty and service agreement.

D. Coordination Drawings (1):
   1. Details of system including but not limited to the following:
      a. Control panels.
      b. Rack arrangements.
      c. Interface method to other systems or equipment.
   2. Integration: Detail interconnections to other systems.

E. Samples:
   1. Factory Samples:
      a. For verification: For each type of termination indicated.
   2. Field Samples (1):
      b. Labeling: Provide label samples and method including a complete cable "Runlist" of cabling required on the project.

1.7 INFORMATIONAL SUBMITTALS
A. Qualification Data:
   1. Source Quality Control Reports:
      a. Submit factory test report from each reel of pre-terminated cable.
2. Special Warranty:
   a. All items of equipment must be new, in current production, currently eligible for warranty and maintenance coverage and have guaranteed availability for a minimum of five (5) years from the Substantial Completion date.

3. Supplier Qualifications:
   a. Certification signed by officer of installation company attesting that proposed system complies with specification requirements:
      1) For multiple firms, an officer from each firm must sign.
   b. For AHJ requirement:
      1) Copy of electrical license.

4. Installer Qualifications:
   a. Provide documentation of certification of manufacturer, supplier, installers, Project Managers and instructors to be utilized on this project. Documentation to include the following:
      1) Manufacturer Training and Certifications:
         a) Submit contractual relationship or technical certification by the respective equipment manufacturers that installer is authorized by that equipment manufacturer to pass through the manufacturer’s certification and equipment warranty to the Owner. Additionally, the equipment manufacturer and Contractor shall accept complete responsibility for the design, installation, certification, operation and physical support for the system.
      2) Industry Training and Certifications:
         a) An integrator or programmer will need to be Extron Control Professional Certified.
   b. Provide reference list of at least five similar installations successfully completed within the last three years within a 100-mile radius. Include scope of work, contact name, title and telephone number.
   c. Project Manager Resume.

5. Manufacturer’s Instructions:
   a. Manufacturer’s recommendations for installing
   b. Provide documentation of certification of manufacturer, supplier, installers and instructors to be utilized on this project.


B. Coordination Data:
   1. Coordination Drawings:
      a. Provide trade coordination drawings of corridor ceilings with limited space where congestion with other systems may be a problem.

C. Field Quality Control Test Reports:
   1. Field Test Reports.

INTEGRATED AUDIO VISUAL SYSTEMS FOR CONFERENCE ROOMS

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1.8  **CLOSEOUT SUBMITTALS**

A. **Operations and Maintenance Data:**

1. **Final Submittal Copy:**
   a. Approved copy of system submittal.
   b. Provide a listing of individual product/device/equipment warranties provided from the manufacturer with expiration dates identified.
   c. Provide a complete listing of devices, installed locations with product serial numbers for product tracking.
   d. Provide all equipment and device licensing information equal to the lifetime of the product with the current system integration.
   e. Provide a complete set of equipment cut sheets, parts list, including maintenance criteria, "troubleshooting" guide, distributor information and service information for all equipment provided.
   f. Provide a complete set of instruction manuals; including complete written programming instructions, programming documentation and system set-up documentation.
   1) Provide an additional quick-start guide with all commonly used procedures for operating the system. Laminate and provide copies during training session.
   g. Provide all test results performed. Include manufacturer's certifications that installed system complies with specification requirements.

2. **Special Warranty Information:**
   a. Provide copy of all documentation including test results sent to manufacturer for system warranty.
   b. Provide all required documentation to the system manufacturer to initiate and ascertain the warranty specified.
   c. Provide warranty of the system by the system manufacturer and guaranteed for the term of the warranty.

3. **Service Contract:**
   a. Provide copy of first service contract terms for Owner evaluation prior to accepting or rejecting service contract.

B. **Record Documents:**

1. **Operation and Maintenance Data:**
   a. Include the following in emergency, operation and maintenance manuals.
   1) Three (3) final corrected copies of catalog data and shop drawings, critical spare parts lists, and manufacturer's operation and maintenance data applicable for the equipment furnished.
   2) Instructions for periodic testing.
   3) Warranty information.
   b. Provide documentation identifying EDID information for all devices and components.

2. **Record Drawings:**
   a. Record drawing indicating locations of all system components.
b. Provide a revised set of system wiring diagrams upon the completion of the installation for subsequent testing of the system to show actual cable routing, connections with other systems, cable lengths values of all equipment as installed and actual signal values as tested.

c. Utilize architectural floor plans for system layout.

3. Training / Demonstration Video.
5. Software CD.
6. Final Field Quality Control Test Reports:
   a. Test report indicating compliance with performance requirements for signal level, system response and signal-to-noise ratio.

1.9 MAINTENANCE MATERIAL SUBMITTALS

A. Spare Parts:
   1. Outlets:
      a. Provide six (6) sets of each outlet configuration complete with jacks, baluns, icons, blanks, etc. that is included on the project for turnover to the Owner for future use.

B. Special Tools:
   1. Tools:
      a. Provide three (3) termination tools to Owner upon completion of the work.
      b. Provide three (3) tamperproof screwdrivers upon completion of the work.

1.10 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturers:
      a. Firms regularly engaged in manufacture of professional quality audio/visual systems, components and accessories, of types, capacities and characteristics required, whose products have been in satisfactory use in similar service for not less than two (2) years.
      b. Provided equipment shall have a guaranteed availability for a minimum of five (5) years from the delivery date through current distribution channels.
   2. Suppliers:
      a. Engage an experienced product supplier who is a factory-authorized sales and service representative regularly engaged in the design and installation of such systems to oversee the installation, trouble-shoot and make final connections at headend equipment.
      b. Supplier shall have represented the product and components being installed for a minimum of two (2) years.
   3. Installers:
      a. Shall be fully capable and experienced in the installation of the systems specified, and have a minimum of five (5) years experience on similar systems.
b. Qualified and certified installers and technicians on staff and assign them to this project. The project shall be staffed at all times by Installers and Technicians who, in the role of lead crafts persons, will be able to provide leadership and technical resources for the remaining crafts persons on the project.

c. Shall be certified by the manufacturing company(-ies) in all aspects of installation and testing of the products described within the systems specifications.

d. Refer to Division 01 Section "Definitions and Standards" for definition of experienced Installer. Upon request submit evidence of such qualifications to the Architect/Engineer.

e. Installer Supervision:

1) Provide a Project Manager as a single point of contact for all activities performed under this section and related equipment sections. The Project Manager shall have a minimum of three (3) years experience in design and installation. The designer must have sufficient experience in this type project(s) as to be able to lend adequate technical support to the field forces during installation, during the warranty period and during any extended warranty periods or maintenance contracts. The Project Manager, or designee thereof, shall be required to attend project meetings as required until project closeout/signoff.

2) The Project Manager shall not change without the Owner consent. The Contractor shall not employ a proposed Project Manager to whom the Owner or Engineer has made reasonable objection.

3) If, in the opinion of the Owner, the Project Manager does not possess adequate qualifications to support the project, the Owner reserves the right to require to assignment of a Project Manager whom possesses the necessary skills and experience required of this project.

4. Instructors:

a. Submit data of the instructor's experience and certified qualifications. Provide documentation that the instructor, who will train operating and maintenance personnel, has received a minimum of 24 hours of training from a recognized technical organization related to this work and two (2) years' experience in the installation of the type of equipment specified.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements:

1. Deliver components properly packaged in factory fabricated containers.

2. Deliver reels, racks, etc. on truck with hydraulic gate or lower carefully using hoist or fork lift. Never drop equipment.

3. Upended heavy equipment, racks, reels, etc. will often arrive damaged. Refuse or receive subject to inspection for hidden damages. Records of delivery date, manufacturer, installation date, any extenuating circumstances along with manufacturer test reports shall be kept on file.

B. Storage and Handling Requirements:

1. Store components in original cartons.

2. Material shall be stored in a secure area with a clean dry space protected from the effects of the weather and away from open fires or sources of heat.

3. Material shall be stored in an area away from construction traffic where construction equipment, falling or flying objects or other materials will not contact the components.
Material shall be stored in an area where chemicals, paint, or petroleum products will not be spilled or sprayed on them.

Cable reels must remain in the upright position. Cable reels must not be stored on their sides. Reels must not be stacked.

Cable reels and lagging must not be stored sitting in direct contact with water or dampness. Reels should be stored on flat, hard surface so that flanges do not sink into the earth. Timbers or metal supports must be placed under the red flanges to provide elevated storage away from water or damp soil.

Reels can be hoisted with a shaft extending through both flanges or cradle both reel flanges between fork lift forks. Never allow forks to touch cable surface or reel wrap. Do not lift by top flange.

Handle equipment and components carefully to avoid breakages, impacts, denting and scoring finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer. Store components in original cartons.

If materials are relocated, an inspection shall be made.

Handle equipment and components carefully to avoid breakages, impacts, denting and scoring finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer.

1.12 WARRANTY

A. Contractor Construction Warranty:

1. Refer to Division 01 requirements.

B. System Warranty:

1. Provide a warranty for the entire system.

2. The warranty shall be backed by the manufacturer’s certified vendor.

3. In the event that the system is being interfaced to existing equipment, that equipment warranty shall be covered by the new warranty implemented with this project.

4. Warranty shall commence when the following construction milestones are met:
   a. Substantial Completion.
   b. Final Engineer acceptance of complete system installation.

C. Special Warranties: Manufacturer specific product/equipment warranties beyond that listed as system operation.

D. EIA Compliance: Comply with the following Electronics Industries Association Standards:


2. Loudspeaker, Dynamic Magnetic Structures, and Impedance, EIA-299-A.

3. Racks, Panels, and Associated Equipment, EIA-310-A.


5. Speakers for Sound Equipment, SE-103.

6. UL Compliance: Comply with requirements of UL 50.

1.13 LICENSES

A. Provide all licenses for all equipment to operate for the lifetime of the installed equipment and system.

1. Licenses shall not expire for the equipment or devices purchased and installed and shall not be required for extending maintenance or operation of the system.

2. Licenses shall cover software and hardware.
PART 2 - PRODUCTS

2.1 PERFORMANCE

A. General: The following minimum performance standards shall be met by the audio visual system.

B. Video:
   1. Provide digital signal integrity of 1080P/60 Hz and 8 bit color throughout system.
   2. Digital Bit Error Rate: Zero.
   3. Digital Signal Data Rate: 4.64 Gbps.

C. Test Signal Paths:
   1. Video: From any and all source inputs (microphones, audiotape units, videotape units, etc.) through all video mixers, switchers, distribution amplifiers, codecs, etc., to all signal destinations.
   2. Prior to ordering equipment, coordinate the frequencies of all wireless devices to prevent unwanted interaction between devices and rooms. This includes, but is not limited to, wireless microphones, assisted listening system devices, wireless control panels, etc.
   3. Video: Recover digital video signals including re-clocker for display port, SDI and HD-SDI and regeneration for DVI and HDMI.

2.2 MANUFACTURERS

A. Careful attention has been made to specify current production models for all equipment listed; however, due to frequent updates of equipment in this field some model numbers may become discontinued. Equipment with the same features and functionality shall be provided as a replacement as recommended by the manufacturer at the time this project is built. In such cases, the nearest equivalent product by the same manufacturer of the discontinued product shall be provided.

B. AV systems and associated related equipment shall be furnished by a single supplier. Coordinate the features of materials and equipment so they form an integrated system with components and interconnections matched for optimum performance of specified functions in the specific rooms.

C. Manufacturers: Subject to compliance with requirements, provide products and components.

D. All equipment is supplied based on Owner IT standards and Specifications.

E. Video Components:
   1. Control Processor:
      a. Supports TouchLink Pro touchpanels
      b. Supports secure industry standard communication protocols
      c. Eight relays for controlling room functions
      d. Eight contact closure ports
      e. Manage, Monitor, and control AV devices using a standard Ethernet network
      f. Power over Ethernet allows the control processor to receive power and control over a single Ethernet cable, eliminating the need for a local power supply.
      g. Manufacturer: Extron 60-1416-01
   2. Scaling Presentation Switcher:
      a. Integrates HDMI, analog video, and audio sources into presentation systems
b. Two DTP inputs, four HDMI inputs, and two universal analog video inputs
d. Available with energy efficient Class D stereo or mono amplifier: 2x50 watts @ 4 ohms; 2x25 watts @ 8 ohms
e. Manufacturer: Extron IN1608 IPCP MA 70 (60-1238-13)

3. HDMI Switchers with EDID Minder:
   a. EDID Minder® automatically manages EDID communication between connected devices
   b. Supports computer video up to 1920x1200, including HDTV 1080p/60 and 2K
   c. Supported HDMI specification features include data rates up to 6.75 Gbps, Deep Color up to 12-bit, 3D, Lip Sync, and HD lossless audio formats
   d. HDCP compliant
   e. Automatic input cable equalization to 50 feet at 1080p/60 with 8-bit color when used with Extron HDMI Pro Series cable
   f. Provides +5 VDC, 250 mA power on the output for external peripheral devices
   g. Manufacturer: Extron SW6 HDMI

4. Contact Closure:
   a. Input selection for remote switchers
   b. Customizable Backlit Buttons
   c. Compatible with Switchers
   d. Manufacturer: Extron CCR 2BLB

5. 80" LCD Flat Panel HDTV:
   b. Resolution: 1920 x 1080.
   c. Contrast Ratio: 4,000:1.
   d. Inputs: 15-Pin HD D-Sub, HDMI, USB, S-Video, composite, Serial.
   e. Built in speakers: 30 watt (15 watt each).
   f. Built in amp.
   g. On/off auto timer.
   h. Manufacturer: Sharp LC-80LE661U.

6. LCD Monitor Wall Mount:
   a. Capacity to support 37" to 60" LCD flat screen monitors.
   b. +12 deg. tilt.
   c. Cord management.
   d. 175 lbs. load capacity.
   e. Provide all accessories and miscellaneous hardware for a complete installation including mounting plates (specific to mounting surface), bolts, etc. to locate monitor as directed in Contract Documents or as determined in the field.
   f. Theft resistant security fasteners.
   g. Manufacturer: Chief PAC525FBP2 or approved equal by Premier.

7. Mini PC:
   a. Intel Pentium and 4th Generation Core i3, i5, and i7 processors
   b. 1600 MHz DDR3 SDRAM; (2) SODIMM slots enabling up to 16 GB, dual channel memory support
c. Ports and connectors: Front: 3.5mm headphone output and microphone jacks, (2) USB 3.0 ports; one port with Fast Charge technology. Rear: (4) USB 3.0 ports, (1) VGA video port, (2) DisplayPort with multistream video ports, (1) RJ-45 network connectors, 3.5mm audio out jack.

d. Power: External 65 W power supply, Active PFC, 87% efficient

e. Manufacturer: HP EliteDesk 800 G1 Desktop Mini Business PC

F. Audio Equipment:
1. Speakers:
   a. Flush Recessed Ceiling Mount Speaker:
      1) 6.5” long throw woofer and a tuned bass reflex enclosure
      2) 8” deep composite back can for plenum environments
      3) Frequency range: 65Hz to 22kHz
      4) Extron SF 26CT (60-1310-03)

G. Blu-ray DiscPlayer with built-in Wi-Fi
1. HDMI Output 1, Coaxial Digital Audio Output, USB Input and Ethernet Connection
2. 9.2W Power Consumption
3. 2.4 GHz WiFi Built-In
4. Manufacturer: Sony BDP-BX370 or pre-approved equal

H. Power Supply: 12V
1. Manufacturer: Extron PS 1210 C (70-775-01)

I. Monitor:
1. 24” Widescreen Full HD LED, 1080p
2. 1920 x 1080 resolution
3. 16:9 Aspect Ratio
4. 1000000:1 Dynamics
5. Inputs: VGA, DVI
6. Integrated Speakers
7. Manufacturer: ASUS VE248H

2.3 CABLES
A. Utilize factory manufactured patch cords in lieu of field terminated cables and components at rack connections and wherever possible.
   1. Utilize industry standard color coded connectors.
   2. Verify patch cord length and routing through sleeves/conduits prior to submittal stage.
   3. Utilize compression type connectors for all field terminated components where required. Provide industry standards identifiable color rings indicating connection type.

B. All cabling shall be plenum rated.

C. Provide all video cabling/connectors to produce the optimal video signal available from the source to the display as available from the equipment and video switcher.

D. Audio/Video Cabling:
   1. Provide audio/video cabling to provide a means of distributing computer video and audio signals from source to display.
2. Shielded Twisted Pair Cabling:
   a. 4-pair, individually foil wrapped.
   b. Overall braided shield.
   c. 26 AWG, solid copper conductors.
   d. Plenum rated.
   e. Manufacturer: Extron #STP201P.

3. One HDMI Female to Female on 10" Pigtail, One 3.5 mm Stereo Mini Jack
   a. Manufacturer: Extron 70-1018-02

4. Single gang wall plate
   a. Manufacturer: Extron CPM101

5. Digital HDMI 2.0 Cables:
   a. Pre-terminated male to male connectors.
   b. Supports resolutions 1920 x 1200 @ 60Hz, and 1080p/60 without cable equalization products.
      1) Cables 13-25 feet in length
      2) Cables up over 25 feet in length:
         a) For lengths over 25ft a point to point extender of CAT will be used.
   c. Manufacturer: Extron HDMI Pro Series.

2.4 AUDIO/VISUAL OUTLETS
   A. Coordinate A/V jacks/couplers with structured cabling system manufacturer's components to provide a complete, uniform, aligned, modular jack assembly.

PART 3 - EXECUTION

3.1 INSTALLERS
   A. Provide experienced and qualified technicians to carry out installation of system equipment and programming.

3.2 EXAMINATION
   A. Verification of Conditions:
      1. Examine areas and conditions under which work is to be performed. Confirm suitability of conditions for installation of products to avoid latent defects in quality of work and function.
      2. Verify that site conditions are satisfactory for installation of Audio Visual Systems and components.
      3. Ensure components and conditions are in compliance with manufacturer's requirements, installation tolerances and other conditions affecting performance.

   B. Pre-Installation Testing:
      1. Identify and document conditions detrimental to proper or timely completion.

   C. Evaluation and Assessment:
      1. Identify and document conditions detrimental to proper or timely completion.
2. Correct unsatisfactory conditions.
3. Do not proceed until unsatisfactory conditions have been corrected.

3.3 PREPARATION
A. Coordinate system requirements with appropriate Divisions.
   1. Review device locations, telecommunication room locations, routings, trunk risers, cable trays, details, and special features.
   2. Coordinate installation requirements with installation of all pathways, sleeves, raceways, outlet boxes, firestopping, bonding, etc.
B. Review Drawings for equipment locations, telecommunication room locations, routing, trunk risers, and special features. Coordinate requirements with appropriate Divisions.
C. Meet with Owner for detailed system design and configuration review. Meeting to explain features, functionality and operability of system. Provide four 4-hour sessions. Include the following in review meeting:
   1. Mounting cabinets, and equipment grounds.
   2. Telecommunications room raceway installations.
   3. Pulling cable.
   4. Terminating cable.
   5. Labeling of cable and equipment.
   6. Meet with Owner and develop a complete labeling convention for Audio Video system, telecommunications rooms, racks, pathways, etc.
   7. Testing cable.
   8. As-built documentation completion.

3.4 PROTECTION OF IN-PLACE CONDITIONS
A. Handle components carefully to avoid breakage, dents, scoring finishes and impacts.
B. Take precautions to protect any surfaces already in-place before continuing with work.
C. Protect everything in existing space from dust and debris in an acceptable manner.
D. Notify Architect/Engineer in writing, of any damage to surrounding areas or surfaces already in place.
E. Keep hands clean when handling ceiling tiles to avoid fingerprints and smudges on the finished installation. Use clean cotton gloves for maximum protection. Ceiling tiles should be handled carefully to protect the face and edges of the tile from damage.
F. Old ceiling tiles can remain in the grid system by being moved to one side and then replaced. Avoid scratching or jamming the tiles.
G. Ceiling tiles shall be removed and stored marked so as to be replaced in the same location. Do not inadvertently rotate a tile.

3.5 INSTALLATION
A. General:
   1. Install equipment in accordance with manufacturer's written instructions.
   2. Install all equipment to industry safety and ergonomic standards and provide full Engineering and technical support throughout the installation process.
3. Provide cabinets, and associated raceway/pathway installations including special wire management auxiliaries.
4. Provide all labor, tools, materials, services and technical knowledge to provide a complete, reliable, system.
5. Install all in a safe, neat, professional, workmanlike manner
6. Repairs: Wherever walls, ceilings, floors, or other building finishes are cut for installation, repair, restore, and refinish to original appearance.

B. General Cabling Requirements:
1. Pull all telecommunications cabling to rack or equipment backboard in telecommunications room from outlet boxes as shown on the Drawings.
2. Conceal all cabling except where specifically indicated otherwise. Surface raceway allowed only where specifically shown on Drawings or approved by Engineer.
3. Do not employ pulling lubricants as they can degrade cable performance
4. Install horizontal cabling open in accessible ceiling spaces. Install Category 6A distribution cabling in separate pathway from other cabling systems.
5. Support cabling 4-feet on center using J-hooks, or a unistrut trapeze configuration approved by the Engineer.
   a. Utilize multiple J-hooks, etc. as required to route all cabling. Provide 30 percent additional usable pathway space at minimum.
   b. Loosely cinch cable bundles with cable ties at each mounting location. Avoid overtightening cable ties.
   c. Cable SAG should be no more than 12 inches between fasteners, minimum 4 inches.
6. Utilize cable tray to support cabling in corridors where available.
   a. Install cabling neatly in tray.
7. Coordinate cabling installation such that it is not supported from new or existing conduits, piping, ductwork, etc. Cabling shall not lie directly on ceiling or be supported by ceiling tie-wires.
8. Utilize metal or plenum rated mounting hardware in ceiling spaces.
9. Properly support all cabling with J-Hooks to stanchion posts under raised/accessible floor locations 2 feet on center. Route cabling to permit air circulation as required by HVAC equipment.
10. Install all cabling parallel and perpendicular to building lines.
11. Install cabling tight to building steel. Avoid locating cabling within 12 inches of lay-in ceilings or access panels.
12. Support vertically routed cabling at each floor. Attach supports such as wire mesh grips as recommended by manufacturer and required by local codes.
13. Traverse common system cables along the same pathway. Multiple runs of cabling terminated at roughly the same geographic area shall traverse the same path whenever possible.
14. Install cable bundles level, taught and tight to building steel. Provide caution during installation so as to not stress or provide excessive tension on the cable.
   a. Pulling tension shall not exceed 25 pounds on a single cable or bundle.
   b. Avoid unnecessary bends and do not exceed a 90 degree bend for any cable.
   c. Do not exceed manufactures bend radius requirements.
15. Cabling shall be routed in metallic conduit to box (located at required height) concealed in new wall construction.
16. Group and tie-wrap all cabling in a neat and orderly manner with Velcro cable ties for observation during above ceiling punch list or other walk-through. Remove ties after approval by Engineer.

17. Install cabling in pathways/raceways without exceeding EIA/TIA maximum fill for that raceway type.
   a. Install cabling in conduits/sleeves to the maximum fill capacity allowed before using an adjacent conduit/sleeve when multiple conduits/sleeves are required.
   b. Install all exposed cabling penetrating walls or through floors through rigid metallic conduit/sleeves or Fire Rated Assembly.
   c. Refer to Division 26 Section "Conduit Rough-In Systems" for conduit/sleeve requirements.

18. Route cabling to avoid elevator shafts, elevator equipment rooms or any areas that contain or store hazardous materials.

19. Avoid sources of electromagnetic interface (EMI) for all voice/data equipment and cables.
   a. Maintain 5 inch minimum from lighting ballast.
   b. Maintain 4 foot minimum from all transformers.
   c. Maintain 1 foot minimum from electric power conductors.
   d. Distances may be reduced if sufficient EMI isolation is provided and prior approval is given by the Engineer.

20. Avoid routing cabling in areas subject to excessive environmental conditions.
   a. Refer to Division 26 Section "Conduit Rough-In Systems" for environmental requirements.

21. Replace entirely any cable jacket that is cut or scored during installation.

22. Terminate all cabling at each cable end as indicated in these Specifications.

23. Test cabling as indicated in these Specifications.

24. Label cabling as indicated in these Specifications.

25. Pull enough slack in the Telecommunications Room to reach the farthest corner and add the distance from floor to ceiling. This allows service slack for future reconfigurations. This is in addition to 3 meters of slack within cabinet.

26. Do not "comb" the cables but leave them placed in a random fashion as cables running parallel could affect high frequency transmission.

C. Adjust and balance all circuits as specified herein. Set all controls and software parameters to render a fully and optimally operating systems and subsystems. All computer-controlled functions shall require complete audio/computer/software setup, balancing, label-entry and documentation.

D. The installer must take such precautions as are necessary to guard against electromagnetic and electrostatic hum, to supply adequate ventilation, and to install the equipment so as to provide maximum safety to the operator.

1. Mount microphones as required to table tops or lecterns as specified by manufacturer. Provide pass-thru grommets into tables as required.

E. The Contractor shall provide suitable filters, traps, and pads for minimizing interference and for balancing the amplifiers and distribution system(s). Items used for balancing and minimizing interference shall be able to pass video, audio, data, and control signals in the speeds and frequency bands selected, in the directions specified, with low loss and high isolation. The Contractor shall install all equipment necessary to meet the requirements each system’s performance standards.
F. All passive equipment shall be connected according to the original equipment manufacturer’s specifications to insure correct termination, isolation, impedance match, and signal level balance.

G. Provide system so that the installation, integration, and combination of equipment actually employed does not produce any undesirable visual effects such as key stoning, banding and shimmering as well as any undesirable aural effects such as signal distortion, noise pulses, glitches, audio hum, poling noise, voltage or spike transients, etc.

H. Provide noise filters and surge protectors for the audio visual system including cabling, equipment racks and display devices to ensure protection from input primary AC power surges and noise glitches are not induced into low voltage data circuits.

I. Provide all necessary scaling equipment to ensure that all images are provided at their maximum resolution to fill the available screen size and aspect ratio the image is presented on.

J. Provide additional branch circuits and power connections to equipment as required. Include and indicate additional power requirements on wiring diagrams at submittal stage for coordination with other Divisions and approval by Engineer.

3.6 EQUIPMENT INSTALLATION

A. Mount all equipment in equipment racks designed to support the equipment.

B. Install systems and components, in accordance with equipment manufacturer's written instructions, in compliance with recognized industry practices, to ensure that the AV system complies with requirements and serves intended purposes.

C. Install equipment properly to avoid causing mechanical stresses, twisting or misalignment of equipment being exerted by clamps, supports, and cabling.

D. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer’s published torque tightening values for equipment connectors. Where manufacturer’s torque requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B, and the National Electrical Code.

E. Remove all dirt, dust and construction debris from all system equipment. Touch-up scratched and marred surfaces to match original finishes to the satisfaction of the Owner/Engineer.

F. Identify, initiate, coordinate and complete all required programming of all equipment for proper and safe operation of equipment and users.

G. Utilize optimal video inputs for connection of video source equipment to switcher and projection units.

H. Properly test all equipment for proper operation and provide final adjustments as required for optimal audio and visual performance.

I. Provide all equipment test reports, signed and certified to Owner and Engineer prior to substantial completion.
J. Trim and Escutcheon Components:
   1. To insure a proper finished appearance, the AV Contractor shall furnish and install trim/escutcheon components at all conditions where AV components pass through the finished ceilings. This would include but not be limited to video projector supports, television monitor/receiver supports and any other component which is not specifically supplied with integral flanges/trim components; i.e. speaker mount, assistance listening devices, etc.
   2. The visible component of any trim should be minimal in size, preferably no wider than 1/2 inch. All trim components at the ceiling plane shall be finished to match the approved ACT ceiling grid system components. The audio visual Contractor should obtain a sample from the Generator Contractor, including any custom color information, or standard color numbers. All trim components shall be submitted to the Architect for review and approval prior to fabrication.

3.7 EQUIPMENT RACK INSTALLATION

A. Provide and install required equipment rack size to accommodate equipment in A/V closet and lectern as shown on drawings.

B. Review available closet configuration for equipment rack and provide racks allowing access to equipment controls and connections at front and back of equipment.

C. Mount equipment racks 60 inches AFF to top of rack.

D. Mount equipment rack to equipment back boxes providing rigidity to support all equipment and allow accessibility to rack.

E. Provide wire management at equipment rack to support all cabling, patch cords, etc. to allow equipment rack accessibility, telescoping, etc. Provide vertical and horizontal lacing bars.
   1. Separate cables with different voltages including but not limited to:
      a. Line level.
      b. Digital control.
      c. Video.
      d. Speaker level audio.
      e. RF.
      f. Power.
   2. Provide 4 inch separation between groups of cables at different voltages.
   3. Provide 90 degrees when crossing cables or different voltages.

F. Mounting shall allow replacement / removal of lamp and filter of projection unit while projection unit is suspended from ceiling.

G. Locate unit at the required distance to allow the maximum use of the projection screen or interactive whiteboard.

H. Route power cord through projector bracket tubing into ceiling space.

I. Ceiling support with wires/chains to support device independently from ceiling grid.

J. Mount racks to allow access to chases, sleeves or slots for cable routing to equipment and devices.

K. Install ground lug and attach ground conductor as recommended by manufacturer.
3.8 WALL MOUNTED EQUIPMENT
A. Coordinate all blocking for support of wall mounted equipment such that equipment does not interfere with rough-in device boxes.
B. Coordinate all wall-mounted brackets supporting wall mounted equipment such that equipment does not interfere with rough-in device boxes.

3.9 DIGITAL SIGNAL PROCESSOR / MIXER INSTALLATION
A. Configuration:
   1. Provide inputs and outputs as shown on the Drawings and identified in the Specifications to meet the requirements intended.
   2. Cascade and link units as required to accommodate inputs and outputs for integration and control.
   3. Coordinate programming with media controller and A/V switcher inputs.
   4. Customize equalizer configuration to the rooms environment including but not limited to tone controls, compressors, limiters, levelers, gates, delays and other devices as recommended by manufacturer.

3.10 MEDIA CONTROLLER PROGRAMMING
A. Coordinate all inputs/outputs from each audio/visual system and incorporate into implementation scenarios for review by the Owner and Engineer. Each scenario shall include the following:
   1. Input Source – Audio/Video.
   2. Outputs – Audio/Video.
   3. Screen option. Icons, Colors, etc.
   4. Controlled Devices – Projection screen, projector, amplifier, etc.
   5. Coordinate projection surface type with projection unit image size for output scenario – projection screen or interactive whiteboard or both as required.
   6. Extron Control Professional Certification is REQUIRED to program the system.
B. Provide programming details, flow charts and code to Owner upon completion and acceptance.
C. Provide a consistent appearance and layout for all user interface throughout the Facility. User interface shall be easy to operate and intuitive.
   1. Utilize Owner standard templates and configurations if available. Customize as required to accommodate system design.
   2. Break up large amounts of information into small, manageable chunks. No more than nine parts to a chunk.
   3. Create standard locations for components of layout.
   4. Maximum of three (3) button presses to perform desired operation.
   5. Utilize icons in addition to text when creating operational buttons:
      a. Provide visual properties queuing user that buttons can be pressed.
      b. Provide visual change identifying that button has been pressed using color and shadowing.
      c. Create buttons with 3 dimensional properties to show depth.
      d. Maintain uniform spacing between buttons.
      e. Utilize verbs as text to describe intended function of buttons.
      f. Group common controls with a single label.
   6. Utilize sans-serif fonts when creating text.
   7. Select font and size that will fit within the button or screen.

INTEGRATED AUDIO VISUAL SYSTEMS FOR CONFERENCE ROOMS

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8. Do not utilize italics or bold italics when creating text.
9. Maintain consistent shapes throughout touch panel design.
10. Color selection shall incorporate a color scheme that is usable when changed to monochrome to be understandable by visual impaired or color blind.

D. Home Screen/Main Screen (Displayed when presentation type is selected from title screen.)
   1. Provide the following groups:
      a. Inputs/Sources to include floor boxes, wall boxes podium auxiliary inputs (laptop) dedicated PC’s, BluRay, document camera, tuner, cameras, etc.
      b. Outputs/Displays to include projectors, monitors, recording/capture devices, video conferencing.
      c. Task Group:
         1) Lighting pop-up menu depending on lighting configuration.
         2) Shades: Open/Close.
         4) Motorized lifts.
         5) Volume control.
      d. Control Group (when selected device control layout will pop-up in center of screen):
         1) BluRay/DVD control.
         2) Document camera control.
         3) Tuner control.
         4) Audio conference control.
         5) Video conference control.
         6) Video preview window.
         7) Camera control.

3.11 LABELING
   A. Provide at equipment (rack) and outlet as required.
   B. All cables, regardless of length, shall be marked with a permanent, self-laminating wrap-around number or letter cable marker at both ends, similar to the Panduit "Pan-Code" system. Labels must be computer-generated for legibility. Wire labels done by hand in the field must be replaced with computer generated labels. There shall be no unmarked cables at any place in the system. Marking codes used on cables shall correspond to codes shown on drawings and or run sheets.
   C. Engraved Faceplates:
      1. Engrave faceplates with input type in Classrooms and finished areas.
   D. Machine Printed Labels:
      1. Self adhesive, smudge resistant vinyl labels for cables and faceplates.
      2. Size labels appropriately for cable diameters; utilize "wrap" installation.
      3. Size labels appropriately to fit in recessed area of faceplate, under available plastic cover or at proper location to identify control buttons or inputs.
      4. Submit samples of labels to verify color of label and size of font for each application.
      5. Center justify all text.
      6. Utilize Hellerman-Tyton Spirit 2100 or approved equal by Rhino Pro, Brother or Panduit.
      7. Engrave faceplates for A/V outlets with input type or provide factory provided (non-removable) markings acceptable to Owner and Engineer.
E. Provide labels at all equipment controls requiring user interface for Owner troubleshooting and easy identification for future re-programming or configuration.

F. Labels shall be affixed free of smudges and fingerprints within three inches of termination.

G. Labels shall be viewable without rotating or removing patch cords or cables.

3.12 GROUNDING

A. Provide intelligible, permanent identification on or adjacent to all patching jacks, connectors, receptacles, terminal blocks meters, indicators, switches, equalizers, mixers, amplifiers, etc. The identification shall clearly indicate the function or circuit.

B. Electrically ground audio visual systems and components.

C. Provide equipment grounding connections for system. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.

D. Refer to "Division 27 Section "Grounding and Bonding for Communications Systems" for acceptable connections and ground conductor sizes for field measured lengths.

E. Grounding Procedures:
   1. In order to minimize problems resulting from improper grounding, and to achieve maximum signal-to-noise ratios, the following grounding procedure shall be adhered to:
      a. System Grounds:
         1) A single primary "system ground" shall be established for the systems in each particular area. All grounding conductors in that area shall connect to this primary system ground. See the perimeter grounding conductor installed under the base construction contract.
            a) The system ground shall be provided in the audio equipment rack for the area, and shall consist of a copper bar of sufficient size to accommodate all secondary ground conductors. A copper conductor having a maximum of 0.1 ohms total resistance shall connect the primary system ground bar to the nearest approved electrical ground. The Contractor shall be responsible for determining if the metallic conduit is properly electrically bonded to the building ground system.
         2) Secondary system grounding conductors shall be provided from all racks, audio consoles, and grounding point for the area. Each of these grounding conductors shall have a maximum of 0.1 ohms total resistance.
         3) Under no conditions shall the AC neutral conductor, either in the power panel or in a receptacle outlet, be used for a system ground.
      b. Video Receptacles:
         1) All video receptacles that are provided and installed by the Contractor shall be insulated from the mounting panel, outlet box, or wireway. Unless otherwise detailed herein, this shall be accomplished by using insulated-from-panel type receptacles.
c. General:

1) Because of the great number of possible variations in grounding systems, it shall be the responsibility of the Contractor to follow ground engineering practice, as outlined above, and to deviate from these practices only when necessary to minimize crosstalk and to maximize signal-to-noise ratios in the audio, video, and control systems.

3.13 CABLE INSTALLATION

A. All wire bundles are to be neat and combed free of cable crossovers.

B. All cables shall be grouped according to the signals being carried. In order to reduce signal contamination, separate groups shall be formed for the following cable families:

1. Power cables.
2. Control cables.
3. Video cables.
4. Audio cables carrying signals less than 20 dBm.
5. Audio cables carrying signals between –20 dBm and +20 dBm.
6. Audio cables carrying signals above +20 dBm.

C. As a general practice, all power cables, control cables, and high level cables shall be run on the left side of an equipment rack as viewed from the rear. All other cables shall be run on the right side of an equipment rack, as viewed from the rear.

D. Cable ties shall be placed at appropriate intervals of no greater than six inches for vertical bundles, two inches for horizontal bundles.

E. All vertical cable bundles shall be attached to the rack frame.

F. All cables shall be continuous lengths without splices. All system wire, after being cut and stripped, shall have the wire strands twisted back to their original lay and be terminated by approved soldered or mechanical means. Except where noted otherwise in the specifications, NO BARE WIRE TERMINATIONS WILL BE ACCEPTED. Heat-shrink tubing shall be used to insulate the ground or drain wire. Unused wires at the end of a cable shall remain unstrapped and shall be laid back and held in place with wire ties.

G. All solder connections shall be made with rosin-core solder using temperature-controlled solder stations. Care shall be taken to avoid cold or cracked solder joints. Any connections that do not appear to be clean and shiny, or which show signs of cracking, shall be resoldered by the Contractor before final acceptance of the system.

H. Mechanical connections using insulated, crimp-type connectors shall be bonded to the connector by soldering the wire to the metal part of the connector.

I. Connections made with screw actuated pressure type terminal strips shall be made by stripping approximately 1/4 inch of insulation from the stranded conductor. Then the untinned wire shall be inserted into the terminal and the screw tightened using a secure fitting precision screwdriver.

J. Terminal blocks, boards, strips, or connectors shall be furnished for all cables which interface with racks, cabinets, consoles, or equipment modules. No audio cables shall run directly to the audio patch panel jacks. Each audio patch panel shall be furnished with an audio terminal block, and all audio cables to and from the audio patch panel shall terminate on this block.

K. All wire markers shall face a common direction.

L. All cables shall have proper connector housing.
M. Cables shall not protrude from the back of racks.

N. All cable entry shall be through the tops of racks or through entrance holes in the base of the rack. No cable shall enter racks through front, rear or side panel openings.

O. All cables (except video and pulse cables, which must be cut to an electrical length) shall be cut to the length dictated by the run. No splices shall be permitted in any pull boxes without prior permission of the Owner’s Representative. For equipment mounted in drawers or on slides, the interconnecting cables shall be provided with a service loop of appropriate length.

P. No cable shall be installed with a bend radius less than that recommended by the cable manufacturer.

Q. Where cables are installed in architectural niches, ensure that the cables are black, unless otherwise directed, to reduce visibility from the audience.

R. Wires and cables shall be insulated to prevent contact with signal or current carrying conductors and 100 percent shielded. Wires or cables used in assembling consoles, panels, equipment cabinets and racks shall be formed into harnesses that are bundled and tied. Harnessed wires or cables shall be combed straight, formed, and dressed in either a vertical or horizontal relationship to equipment, controls, components or terminations.

S. Harnesses with intertwined members are not acceptable. Each wire or cable that breaks out from a harness for connection or termination. Tie off at that harness or bundle point, and be provided with an ample neatly formed service loop.

T. Provide system input and output polarity as recommended by the original equipment manufacturer. Ensure each color-coded wire or cable is connected and terminated to maintain system polarity to be at least the same quality of professional audio systems. Reflect all color codes, wire and cable terminations on the system’s Drawings of Record as required herein.

3.14 FIELD QUALITY CONTROL

A. Wiring Methods:

1. Install wiring in raceways except within lecterns, desks, racks, and except in accessible ceiling spaces, where open cable wiring methods may be used. Use UL-listed plenum cable.

2. Install cabling in raceways in all areas with exposed structure.

3. Conceal all exposed furniture wiring in approved cable enclosure to make inconspicuous.

4. Cable shall be homerun per manufacturer’s specifications.

5. Control Circuit Wiring: Provide number of conductors as recommended by system manufacturer to provide control functions indicated, specified or to meet design intent.

6. Install cables and raceways parallel and perpendicular to surfaces or exposed structural members, and follow surface contours. Secure and support cables/conduits by straps or similar fittings so designed and installed as not to damage the cables. Secure cable at intervals not exceeding 30 inches and not more than 6 inches from every cabinet, box, or fitting.

7. Wiring within Enclosures: Provide adequate length of conductors to allow sliding cabinet to open and rotate 90 degrees. Bundle, lace, and train the conductors to terminal points with no excess. Provide and use lacing bars.

8. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes, terminal cabinets, and equipment enclosures.
9. Identification of Conductors and Cables: Use color coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with system wiring diagrams.

10. Provide physical isolation from each other for microphone, line level, speaker, and power wiring. Run in separate raceways or provide 12-inch minimum separation where exposed or in same enclosure. Provide additional physical separation as recommended by equipment manufacturer.

B. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

C. Manufacturer’s Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the pretesting, testing, and adjustment of the system where deemed necessary.

D. Before final acceptance of the system, manufacturer-supplier of system shall, in presence of Owner’s representative, test each and every component and device in the system. Test shall be documented with signed copy submitted to the Owner and Architect/Engineer.

E. The system shall be physically inspected by the Owner's representative and the Architect/Engineer to assure that all equipment is installed in a neat and workmanlike manner as called for in the plans and specifications.

F. Upon completion of the system installation, and after circuitry has been energized with the normal power source, test the system to verify the following:

1. All components are operational and functioning properly to the system designs intent.
2. Perform all necessary adjustments and balancing of all signal and amplifier level controls to insure proper operation. Ensure output levels of sources are equal.
3. The complete system is free from grounds, open and shorts except for made grounds required by the system installation.
4. The system is free of hum or noise including but not limited to ground loops, improper impedance matching or improper shielding.
5. Configure signal processor to perform all gating, precedence, equalization and compression to provide optimal performance.
6. Correct all of the above and retest to demonstrate compliance where required by Engineer.
7. All testing shall be documented. Provide a signed copy to the Owner/Engineer verifying the system is complete, and fully functional.
8. Make observations to verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

G. Contractor System Checkout:

1. Before acceptance tests are schedule, perform system checkout based upon an approved testing procedure for the systems. Contractor to furnish all required test equipment and perform all work necessary to determine and/or modify performance of the system to meet the requirements of this specification. Submit testing system for approval from the Owner’s Representative. The following is an example test procedure:

H. Provide written records of all test results in spreadsheet form.

I. Check all control functions, from all controlling devices to all controlled devices, for proper operations.

J. Maintain documentation of all performance tests for reference by the Owner’s Representative during the System Acceptance Tests.

K. System Acceptance Tests:
1. System Acceptance Tests will not be performed until the Contractor’s System Checkout has been completed and the test results have been reviewed. The System Acceptance Tests will be supervised by the Owner’s Representative and will consist of the following:
   a. A physical inventory will be taken of all equipment on site and will be compared to equipment lists in the contract documents.
   b. The operation of all system equipment shall be demonstrated by the Contractor.
   c. Both subjective and objective tests will be required by the Owner’s Representative to determine compliance with the specifications. The Contractor shall be responsible for providing test equipment for these tests.
   d. All final “as-built” drawings, run sheets, manuals, and other required documents, as detailed in the previous section, shall be on hand.
   e. In the event further adjustment is required, or defective equipment must be repaired or replaced, tests may be suspended or continued at the option of the Owner’s Representative.

L. Occupancy Adjustments:
   1. When requested by the Architect, within one (1) year of date of Substantial Completion, provide on-site assistance in re-programming systems to suit user operation and actual, occupied conditions.
   2. Provide up to three (3) visits for this work.

M. Test Equipment:
   1. Each Contractor is responsible for furnishing all test equipment required to test the system in accordance with the parameters specified. Unless otherwise stated, the test equipment shall not be considered part of the system. Each Contractor shall furnish test equipment of accuracy better than the parameters to be tested.
   2. The test equipment furnished by each Contractor shall have a calibration tag of an acceptable calibration service dated not more than 12 months prior to the test. As part of the submittal, a test equipment list shall be furnished that includes the make and model number of the following type of equipment as a minimum:
      a. Oscilloscope.
      b. Spectrum Analyzer.
      c. Signal Level Meter.
      d. Volt-Ohm Meter.
      e. SPL Meter.
      f. SPL Calibrator.
      g. Sine wave and random Noise Generator.
      h. Audio Amplifier with external speaker.
   3. Sound System Speaker Testing:
      a. Utilize impedance meter to measure true impedance of circuit prior to connection of amplifiers. Identify and correct short circuits, open loudspeaker lines, transformers installed backwards, and total load of the speaker system. Document measurements and provide documentation with closeout.
   4. Provide system equalization adjusting loudspeaker output to compensate for room frequency response. Utilize pink noise generator and real time analyzer to adjust equalizer as required. Include documentation of settings with closeout documentation.
3.15 CLEANING

A. Clean all equipment on a day-to-day basis and final cleaning of all equipment prior to turning over to the Owner. Clean to the satisfaction of the Owner's representative.

B. Equipment:
   1. Clean all equipment completely inside and out prior to testing.
   2. Furnish cleaning consisting of vacuuming all panels, terminations, enclosures (inside and out), etc. Thoroughly dry wet equipment or if contains moisture before testing.

C. Raceways and Junction Boxes:
   1. Blow out and dry all raceways and conduits prior to installation of cabling.

D. Audio/Visual Closets and Lecterns:
   1. Sweep rooms clean and all garbage remove from the site upon completion of cleaning equipment as described in above paragraph, but before testing equipment.
   2. Ensure that once equipment and room are cleaned and tested, the area remains clean and the doors remain closed until completion of job. If rooms and equipment are subject to dust and moisture after testing equipment, reclean equipment to the same specifications.

3.16 CLOSE OUT ACTIVITIES

A. Record cable runway locations and sizes onto project blueprints.
   1. Record sizes of pathways, location of cable routings and system rack elevations as installed on the project blueprints.
   2. Submit as-built documents for Engineer's review and approval.

B. Owner's Instructions:
   1. Operation and Maintenance Data: Provide approved shop drawings with modifications as required by Engineer's instructions or project progression. Include operating and maintenance instructions, parts inventory listing, purchase source listing, emergency instructions, assembly/disassembly and termination diagrams, and wire administration data as specified herein.
   2. Provide any additional information as required per the manufacturer's requirements for required warranties.

C. Software Documentation:
   1. Actual source code must be provided. The software developer shall retain intellectual property rights to the operation software. The Owner shall be granted a license in perpetuity for use. Include the following:
      a. All source code becomes the exclusive property of Owner.
      b. All source code changes must be fully documented.
      c. All custom programs for remote control system touch panels, and other programmed devices, are the property of the Owner, and be submitted with the final systems documentation in the CD-ROM. Include a copy of the current program with the "as-built" drawings, in a magnetically protective envelope.
      d. Subsequent to system certification, implement source code changes and/or additional programming, warranty changes by the vendor for a period of one (1) year, with the vendor responsible for the diagnosis and repair. Ensure that the current program is saved to a CD, and stored as outlined above.
D. Training:
   1. Furnish the services of a factory-trained engineer or technician for two 4-hour periods to instruct the Owner’s personnel. Include corrective and preventive maintenance of each system’s equipment. Schedule training at the convenience of the Owner.
   2. Furnish the services of a representative of the systems; familiar with the functions and operation of the equipment, for two (2) 4-hour periods to train selected Owner personnel. Instructions provided for staff personnel in each area where new equipment is provided under this contract. When multiple locations are involved, classes will be grouped. Coordinate period of training with Owner to ensure all shifts receive the required training. Utilize digital camera to record training session and provide two copies of training to Owner.

3.17 SPARE EQUIPMENT/PARTS
   A. Dropouts.

3.18 TURNOVER MEETING
   A. Meeting:
      1. Upon completion of all work, coordinate a meeting with the Owner and Owner's Representative at the site to provide all as-built documentation, certifications, test reports, spare parts, and additional manuals, etc. Turn over prior to completion of final punch list.
      2. Provide in-depth review of all documentation and equipment to Owner for acceptance.

END OF SECTION 274111
PART 1 - GENERAL

1.1 SUMMARY

A. This section includes a sound system and all associated equipment for amplifying and distributing live audio and various other sources. The work included in this Section consists of furnishing all labor, material, services, and skilled supervision necessary for the construction, erection, installation, and connection of all circuits, apparatus, and equipment specified herein and as shown on Drawings.

B. Work in this section includes, but is not limited to the following items:
   1. Speakers.
   3. Provide labor, materials, equipment and services to perform operations required for the complete installation and related work as required in Contract Documents.
   5. Media Player.
   6. AV Cabling.

C. Requirements of Division 20 Section "Common Work Results, Division 21 through 28" apply to this Section.

D. Coordinate all work with Division 26 for proper pathways and rough-in requirements.

E. Refer to applicable Division 26 Sections for raceways, electrical boxes and fittings, and wiring/cabling required in conjunction with installation of Sound System.

F. Requirements specified in the following Division 26 sections apply to this Section:
   1. Section "Basic Division 26 Requirements."
   2. Section "Raceways."
   3. Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
   4. Section "Hangers and Supports for Electrical Systems."
   5. Section "Electrical Identification."
   6. Section "Grounding and Bonding for Electrical Systems."
   7. Section "Conduit Rough-In Systems."

G. Requirements specified in the following Division 27 sections apply to this Section:
   1. Section "Basic Division 27 Requirements."
   2. Section "Structured Telecommunications Cabling System."
   3. Section "Grounding and Bonding for Communications Systems."

1.2 PRICE AND PAYMENT PROCEDURES

A. Allowances – Refer to Division 01, General Requirements for allowance information.

B. Unit Prices – Refer to Division 01, General Requirements for unit price information.
1.3 REFERENCES

A. If this document and any of the documents listed herein are in conflict, then the more stringent requirement shall apply. All documents listed are believed to be the most current releases of the documents; this Division is responsible to determine and adhere to the most recent release when developing the proposal for installation.


B. EIA Compliance: Comply with the following Electronics Industries Association Standards:

2. Loudspeaker, Dynamic Magnetic Structures, and Impedance, EIA-299-A.
3. Racks, Panels, and Associated Equipment, EIA-310-A.
5. Speakers for Sound Equipment, SE-103.
6. UL Compliance: Comply with requirements of UL 50.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate with other work, including electrical wiring work, cabinet placement, casework/millwork and structured telecommunications cabling, as necessary to properly interface installation of this system with other work.
2. Coordinate all work with Division 26 for proper pathways and rough-in requirements; including but not limited to, size and bend radius.
3. Coordinate with Owner procured equipment, and associated manufacturer installation instructions.
4. Verify all equipment, device plates and speaker colors in finished spaces with architect at the time of submittal unless colors are specifically called out.

B. Pre-Installation Meetings:

1. Meet with Owner for detailed system design and configuration review. Meeting to explain features, functionality and operability of system. Provide one (1) 1-hour sessions.

C. Sequencing:

1. Sequence system installation work with other work to minimize possibility of damage and soiling system during remainder of construction period.
1.5 PRODUCTS FURNISHED
   A. All installation practices shall be in accordance with, but not limited to, these specifications and
drawings. Installation shall be performed in accordance with the applicable standards,
requirements and recommendations of authorities having jurisdiction.

1.6 SUBMITTALS
   A. General: Submit the following in accordance with Conditions of Contract and Division 01
   Specification Sections, and Division 27 Section "Basic Division 27 Requirements."
   B. Submittals shall be provided based on specification number and be inclusive of the equipment
within that section. Equipment submitted from multiple sections under a single cover, will not be
reviewed.
      1. Provide six (6) copies of all submittal information for review.
      2. Provide electronic copy of all submittal information in PDF Format/Microsoft Word/Excel
         Format.

1.7 ACTION SUBMITTALS
   A. Product Data: Submit for each type of product specified.
      1. Provide manufacturer's literature to include all information necessary to confirm that
the proposed system is in complete compliance with the Specifications.
      2. Provide all information in a single, complete bound submission.
      3. Table of Contents identifying equipment lists with numbered pages corresponding to
equipment/device locations within submittal for quick reference.
      4. System Scope of Work narrative including Owner meetings, Owner reviews, programming
approval, milestones, and testing.
      5. Equipment Information:
         a. All equipment shall be specific to this section only unless required for integration.
            1) Manufacturer’s specifications and descriptive literature.
            2) Manufacturer’s recommended installation procedures.
            3) Equipment/device quantities.
            4) Equipment/device product information sheets with submission designated,
               installation information, color/finish options, etc.
            5) Program information sheets.
            6) Coordination requirements with all trades.
            7) Program layout diagrams, riser diagrams, wiring diagrams, rack elevations,
               etc. Utilize Architectural, Electrical, and Communication symbology to be
               consistent with Owner's standards.
            8) Deviations from contract documents, if any, highlighted with specific
               explanation and identification requiring Architect/Engineer specific approval.
            9) Manufacturer required information for base and extended warranties
               including submission requirements and timeframes.
           10) Estimated equipment heat loads and power requirements. Submit
               qualifications based on quality assurance requirements for manufacturer,
               supplier, installer, trainer, etc.
           11) Provide secondary submittal for systems requiring programming and Owner
               input, review, and approval after Programming meeting, sequence of
               operations review, etc. Provide all information in spreadsheet format in
               electronic and hardcopy.
           12) Training outline.
Sample test reports.

b. Provide a list with references of at least three (3) installations of equivalent or larger systems installed within the last two (2) years.

1) Provide Facility location and name.
2) Owner's or User's name, address, and telephone (including fax) numbers.
3) Date of Project Start and Date of Final Acceptance by Owner.
4) System Project Number.
5) Brief (three paragraphs minimum) description of each system's function, operation, and installation.

c. Provide certification with data substantiating that products comply with requirements of the Contract Documents. Furnish UL File number with product data as submitted.

B. Certification Letter: Provide certification letter in lieu of submittal. Refer to Division 01 requirements for procedure.

C. Shop Drawings (Submit for each):
   1. Layout Drawings:
      a. Submit scaled system layout drawings using architectural floor plans indicating head end equipment layout and dimensions. Include layout of equipment in relation to room size and other existing and new system equipment in that room. Include equipment layout and rack elevations.
         1) Indicate connections to equipment supplied by others.
      b. Submit scaled system layout drawings using architectural floor plans for system equipment indicating cable types, amplifiers, electrical connections, taps, etc., as designed for this project.
         1) Include tap values, db levels and other important system configuration values.
         2) Include lengths of all trunk cables, feeder cables, and horizontal cables.
         3) Provide building room numbers and diagrams specific to this project.
         4) All panels, plates and designation strips, including details relating to terminology, engraving, finish and color.
         5) Detailed wiring for connectivity of other interfaces. Differentiate clearly intersystem connections.
         6) Wiring Diagrams detailing wiring for power, signal, and control differentiating clearly between manufacturer-installed wiring and field-installed wiring. Identify terminal numbers and wiring color codes to facilitate installation, operation, and maintenance.
         7) Remote control panel design (to include "live" interactive electronics format).
         8) All equipment racks, cabinets, consoles, tables, carts, support bases and shelves.
         9) All non-factory equipment modifications.
        10) Front mechanical drawings of each equipment rack.
        11) System functional block drawings, including those for audio and video subsystems.
        12) Cable labeling plan.
   2. Factory Quality Control Test Reports:
      a. Warranty and service agreement.
D. Coordination Drawings:
   1. Details of system including but not limited to the following:
      a. Console layouts.
      b. Control panels.
      c. Rack arrangements.
      d. Interface method to other systems or equipment.
   2. Integration: Detail interconnections to other systems.

1.8 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. Source Quality Control Reports:
      a. Submit factory test report from each reel of preterminated cable.
   2. Special Warranty:
      a. All items of equipment must be new, in current production, currently eligible for warranty and maintenance coverage and have guaranteed availability for a minimum of five (5) years from the Substantial Completion date.
   3. Supplier Qualifications:
      a. Certification signed by officer of installation company attesting that proposed system complies with specification requirements:
         1) For multiple firms, an officer from each firm must sign.
      b. For AHJ requirement:
         1) Copy of electrical license.
   4. Installer Qualifications:
      a. Provide documentation of certification of manufacturer, supplier, installers, project managers and instructors to be utilized on this project. Documentation to include the following:
         1) Manufacturer Training and Certifications:
            a) Submit contractual relationship or technical certification by the respective equipment manufacturers that installer is authorized by that equipment manufacturer to pass through the manufacturer’s certification and equipment warranty to the Owner. Additionally, the equipment manufacturer and Contractor shall accept complete responsibility for the design, installation, certification, operation and physical support for the system.
2) Industry Training and Certifications:
   a) The Audio Visual Technicians assigned to the system shall be fully
      trained, qualified, and carry valid and current industry certifications
      regarding the engineering, installation, operation, programming and
      testing of audio visual technologies. At least one (1) each InfoComm
      International CTS-D and InfoComm International CTS-I or equal
      certifications by NSCA shall be assigned to oversee the complete
      design and installation of the system. The Contractor shall provide
      formal written evidence of current industry certification for the
      designer(s) and installer(s) dedicated to this project as a part of their
      submittal before being allowed to commence work on the system.
   b. Provide reference list of at least five similar installations successfully completed
      within the last three years within a 100 mile radius. Include scope of work, contact
      name, title and telephone number.
   c. Project Manager Resume.

5. Manufacturer’s Instructions:
   a. Manufacturer’s recommendations for installing
   b. Provide documentation of certification of manufacturer, supplier, installers and
      instructors to be utilized on this project.

B. Coordination Data:
   1. Coordination Drawings:
      a. Provide trade coordination drawings of corridor ceilings with limited space where
         congestion with other systems may be a problem.

C. Field Quality Control Test Reports:
   1. Field Test Reports.

1.9 CLOSEOUT SUBMITTALS

A. Operations and Maintenance Data:
   1. Final Submittal Copy:
      a. Approved copy of system submittal.
      b. Provide a listing of individual product/device/equipment warranties provided from
         the manufacturer with expiration dates identified.
      c. Provide a complete listing of devices, installed locations with product serial
         numbers for product tracking.
      d. Provide all equipment and device licensing information equal to the lifetime of
         the product with the current system integration.
      e. Provide a complete set of equipment cut sheets, parts list, including maintenance
         criteria, “trouble-shooting” guide, distributor information and service information
         for all equipment provided.
      f. Provide a complete set of instruction manuals; including complete written
         programming instructions, programming documentation and system set-up
         documentation.
      1) Provide an additional quick-start guide with all commonly used procedures for
         operating the system. Laminate and provide copies during training session.
2. Provide all test results performed. Include manufacturer's certifications that installed system complies with specification requirements.

3. Special Warranty Information:
   a. Provide copy of all documentation including test results sent to manufacturer for system warranty.
   b. Provide all required documentation to the system manufacturer to initiate and ascertain the warranty specified.
   c. Provide warranty of the system by the system manufacturer and guaranteed for the term of the warranty.

4. Service Contract:
   a. Provide copy of first service contract terms for owner evaluation prior to accepting or rejecting service contract.

B. Record Documents:
1. Operation and Maintenance Data:
   a. Include the following in emergency, operation and maintenance manuals.
      1) Three (3) final corrected copies of catalog data and shop drawings, critical spare parts lists, and manufacturer's operation and maintenance data applicable for the equipment furnished.
      2) Instructions for periodic testing.
      3) Warranty information.

2. Record Drawings:
   a. Record drawing indicating locations of all system components
   b. Provide a revised set of system wiring diagrams upon the completion of the installation for subsequent testing of the system to show actual cable routing, connections with other systems, cable lengths values of all equipment as installed and actual signal values as tested.
   c. Utilize architectural floor plans for system layout.

4. Software CD.
5. Provide all programming information to Owner for future use for editing system operation or re-installation. Include with programming editing and operating systems
6. Final Field Quality Control Test Reports:
   a. Test report indicating compliance with performance requirements for signal level, system response and signal-to-noise ratio.

1.10 QUALITY ASSURANCE
A. Qualifications:
1. Manufacturers:
   a. Firms regularly engaged in manufacture of professional quality cable tray systems, components and accessories, of types, capacities and characteristics required, whose products have been in satisfactory use in similar service for not less than two (2) years.
   b. Provided equipment shall have a guaranteed availability for a minimum of five (5) years from the delivery date through current distribution channels.
2. Suppliers:
   a. Engage an experienced product supplier who is a factory-authorized sales and service representative regularly engaged in the design and installation of such systems to oversee the installation, trouble-shoot and make final connections at headend equipment.
   b. Supplier shall have represented the product and components being installed for a minimum of two (2) years.

3. Installers:
   a. Shall be fully capable and experienced in the installation of the systems specified, and have a minimum of five (5) years experience on similar systems.
   b. Qualified and certified installers and technicians on staff and assign them to this project. The project shall be staffed at all times by Installers and Technicians who, in the role of lead crafts persons, will be able to provide leadership and technical resources for the remaining crafts persons on the project.
   c. Shall be certified by the manufacturing company(-ies) in all aspects of installation and testing of the products described within the systems specifications.
   d. Refer to Division 01 Section "Definitions and Standards" for definition of experienced Installer. Upon request submit evidence of such qualifications to the Architect/Engineer.
   e. Installer Supervision:
      1) Provide a Project Manager as a single point of contact for all activities performed under this section. The Project Manager shall have a minimum of three (3) years experience in design and installation. The designer must have sufficient experience in this type project(s) as to be able to lend adequate technical support to the field forces during installation, during the warranty period and during any extended warranty periods or maintenance contracts. The Project Manager, or designee thereof, shall be required to attend project meetings as required until project closeout/signoff.
      2) The project manager shall not change without the Owner consent. The contractor shall not employ a proposed Project Manager to whom the Owner or Engineer has made reasonable objection.
      3) If, in the opinion of the Owner, the Project Manager does not possess adequate qualifications to support the project, the Owner reserves the right to require to assignment of a Project Manager whom possesses the necessary skills and experience required of this project.

4. Instructors:
   a. Submit data of the instructor's experience and certified qualifications. Provide documentation that the instructor, who will train operating and maintenance personnel has received a minimum of 24 hours of training from a recognized technical organization related to this work and two (2) years experience in the installation and operation of the type of equipment specified.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements:
   1. Deliver components properly packaged in factory fabricated containers.
   2. Deliver reels, racks, etc. on truck with hydraulic gate or lower carefully using hoist or fork lift. Never drop equipment.
3. Upended heavy equipment, racks, reels, etc. will often arrive damaged. Refuse or receive subject to inspection for hidden damages. Records of delivery date, manufacturer, installation date, any extenuating circumstances along with manufacturer test reports shall be kept on file.

B. Storage and Handling Requirements:
   1. Store components in original cartons.
   2. Material shall be stored in a secure area with a clean dry space protected from the effects of the weather and away from open fires or sources of heat.
   3. Material shall be stored in an area away from construction traffic where construction equipment, falling or flying objects or other materials will not contact the components.
   4. Material shall be stored in an area where chemicals, paint, or petroleum products will not be spilled or sprayed on them.
   5. Cable reels must remain in the upright position. Cable reels must not be stored on their sides. Reels must not be stacked.
   6. Cable reels and lagging must not be stored sitting in direct contact with water or dampness. Reels should be stored on flat, hard surface so that flanges do not sink into the earth. Timbers or metal supports must be placed under the red flanges to provide elevated storage away from water or damp soil.
   7. Reels can be hoisted with a shaft extending through both flanges or cradle both reel flanges between fork lift forks. Never allow forks to touch cable surface or reel wrap. Do not lift by top flange.
   8. Handle equipment and components carefully to avoid breakages, impacts, denting and scoring finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer.
   9. If materials are relocated, an inspection shall be made.
   10. Handle equipment and components carefully to avoid breakages, impacts, denting and scoring finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer.

C. Packaging Waste Management:
   1. Dispose of all packing materials and include cost of packing materials disposal and handling as part of the base bid.

1.12 WARRANTY
A. Contractor Construction Warranty:
   1. Refer to Division 01 requirements.

B. System Warranty:
   1. Provide a warranty for the entire system.
   2. The warranty shall be backed by the manufacturer’s certified vendor.
   3. In the event that the system is being interfaced to existing equipment, that equipment warranty shall be covered by the new warranty implemented with this project.
   4. Warranty shall commence when the following construction milestones are met:
      a. Substantial Completion.
      b. Final engineer acceptance of complete system installation.

C. Special Warranties: Manufacturer specific product/equipment warranties beyond that listed as system operation.
   1. Amplifier(s) supported with three (3) year extended warranty.
1.13 LICENSES
A. Provide all licenses for all equipment to operate for the lifetime of the installed equipment and system.
   1. Licenses shall not expire for the equipment or devices purchased and installed and shall not be required for extending maintenance or operation of the system.
   2. Licenses shall cover software and hardware.

1.14 SEQUENCE AND SCHEDULING
A. Coordinate with other work, including electrical wiring work and structured telecommunications cabling.
B. Sequence system installation work with other work to minimize possibility of damage and soiling system during remainder of construction period.

1.15 COORDINATION
A. Coordinate all work to be performed with actual field and project conditions. At a minimum, perform the following tasks prior to submitting bids or shop drawings for the project:
   1. Perform field investigations to determine all necessary incidental items which will be required for complete and proper installation of all work. Verify all items affecting the bid price prior to bidding.
   2. Perform all necessary field measurements to provide complete, accurate, and coordinated shop drawing submittals.
   3. Organize and attend all necessary coordination meetings required to assure proper coordination and installation of all related work included in the project.

1.16 PROJECT MANAGEMENT
A. At the time of Contract execution, the A/V Contractor shall assign a Project Manager to this Project that will be responsible for administering all correspondence between the A/V Contractor, administering all other trades, Construction Manager, Owner and Architect/Engineer. The Project Manager shall also be responsible for the following:
   1. Attending all meetings and reporting on project status, schedule, deliverables, manpower, shutdowns, etc.
   2. Approving all submittal information.
   3. Supervising and providing implementation, installation, testing, certification cutover, acceptance and documentation for all installed work.
B. The project team will consist of a Project Engineer that will be responsible for all on-site day-to-day tasks, installation, and data collection and programming at the site.
C. Kickoff Meeting – Purpose of the meeting is to introduce the project team to the Owner and Engineer and to identify any schedule conflicts, equipment lead times, review any previously approved substitutions, environmental and space requirements, additional data/electrical requirements and customer responsibilities.
   1. Provide a list of milestone dates to meet the installation schedule including shop drawing review, equipment delivery, programming review, customer review, etc.
D. Programming Design Meetings:
1. The A/V Contractor shall provide a comprehensive block diagram or flow chart for each A/V system to present to the Owner the intuitive operation of all components controlled by the touch screen/controller in each room.

2. Provide a configuration review session for the operation of the system component sources and outputs for the Owner's review and input prior to beginning programming. Be prepared with sample control scenarios and each system input/output criteria for the design session. Provide follow-up information in submittal format for written approval.

E. Installation Review:

1. Complete a review meeting with the Owner and review all the required inputs/outputs and scenarios discussed in the design meetings and implement to verify with all the equipment in operating condition.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. All items of equipment including wire and cable shall be designed by the manufacturer supplier to operate as a complete system and shall be accompanied by complete service notes and drawings detailing all inter-connections.

B. Equipment shall be listed by Underwriters Laboratories, Inc. Each major component shall bear the manufacturer's name and catalog number.

C. Careful attention has been made to specify current production models for all equipment listed, however due to frequent updates of equipment in this field some model numbers may become obsolete by the time this project is built. In such cases the nearest equivalent product by the same manufacturer is required.

2.2 EQUIPMENT

A. Contractor shall consult with owner's IT department prior to purchase of sound equipment and systems as defined in the IT project product specification.

2.3 SYSTEM REQUIREMENTS

A. General: Provide a complete and fully functional sound system using materials and equipment of types, sizes, ratings, and performance indicated. Use materials and equipment that comply with referenced standards and manufacturers' standard design and construction in accordance with published product information. Coordinate the features of materials and equipment so they form an integrated system with components and interconnections matched for optimum performance of specified functions.

2.4 WIRING

A. Speaker Cable - West Penn WP 292, 20 AWG stranded tinned copper, polypropylene insulated, twisted pair, aluminum - polyester shield, 22 AWG stranded tinned copper drain wire.

B. Where 4,8 ohm speakers or 70 volt speakers are used, 12 or 14 AWG wire is required based on power and distance West Penn WP 295 (14) or WP 296 (12).
PART 3 - EXECUTION

3.1 INSTALLERS
   A. Provide experienced and qualified technicians to carry out installation of system equipment and programming.

3.2 EXAMINATION
   A. Verification of Conditions:
      1. Examine areas and conditions under which work is to be performed. Verify that site conditions are satisfactory for installation of cable and components.
      2. Ensure components and conditions are in compliance with manufacturer’s requirements, installation tolerances and other conditions affecting performance.
   B. Pre-Installation Testing:
      1. Identify conditions detrimental to proper or timely completion.
   C. Evaluation and Assessment:
      1. Correct unsatisfactory conditions.
      2. Do not proceed until unsatisfactory conditions have been corrected.

3.3 PREPARATION
   A. Coordinate system requirements with appropriate Divisions.
      1. Review device locations, equipment room locations, routings, and special features.
      2. Coordinate installation requirements with installation of all pathways, sleeves, raceways, outlet boxes, firestopping, bonding, etc.
   B. Review Drawings for equipment locations, routing, and special features. Coordinate requirements with appropriate Divisions.
   C. Meet with Owner for detailed system design and configuration review. Meeting to explain features, functionality and operability of system. Provide one (1) 4-hour session. Include the following in review meeting:
      1. Customized configuration and programming
      2. Equipment room raceway installations.
      3. Pulling cable.
      4. Terminating cable.
      5. Labeling of cable and equipment.
      6. Meet with Owner and develop a complete labeling convention for Sound system.
      7. Testing cable.
      8. As-built documentation completion.
   D. Protection Of In-Place Conditions:
      1. Handle components to be reused carefully to avoid breakage, dents, scoring finishes and impacts.
      2. Take precautions to protect any surfaces already in-place before continuing with work.
      3. Protect everything in existing space from dust and debris in an acceptable manner.
      4. Notify Architect/Engineer in writing, of any damage to surrounding areas or surfaces already in-place.
5. Keep hands clean when handling ceiling tiles to avoid fingerprints and smudges on the finished installation. Use clean cotton gloves for maximum protection. Ceiling tiles should be handled carefully to protect the face and edges of the tile from damage.

3.4 INSTALLATION

A. General Cabling Requirements:

1. Pull all AV and telecommunications cabling to millwork.
2. Conceal all cabling except where specifically indicated otherwise.
3. Do not employ pulling lubricants as they can degrade cable performance.
4. Install horizontal cabling open in accessible ceiling spaces.
5. Support cabling 4-feet on center using J-hooks, or a unistrut trapeze configuration approved by the Engineer.
   a. Utilize multiple J-hooks, etc. as required to route all cabling. Provide 30% additional usable pathway space at minimum.
   b. Loosely cinch cable bundles with cable ties at each mounting location. Avoid over-tightening cable ties.
   c. Cable sag should be no more than 12" between fasteners, minimum 4".
6. Coordinate cabling installation such that it is not supported from new or existing conduits, piping, ductwork, etc. Cabling shall not lie directly on ceiling or be supported by ceiling tie-wires.
7. Utilize metal or plenum rated mounting hardware in ceiling spaces.
8. Install all cabling parallel and perpendicular to building lines.
9. Install cabling tight to building steel. Avoid locating cabling within 12 inches of lay-in ceilings or access panels.
10. Support vertically routed cabling at each floor. Attach supports such as wire mesh grips as recommended by manufacturer and required by local codes.
11. Traverse common system cables along the same pathway. Multiple runs of cabling terminated at roughly the same geographic area shall traverse the same path whenever possible.
12. Install cable bundles level, taught and tight to building steel. Provide caution during installation so as to not stress or provide excessive tension on the cable.
   a. Pulling tension shall not exceed 25 lbs. on a single cable or bundle.
   b. Avoid unnecessary bends and do not exceed a 90 degree bend for any cable.
   c. Do not exceed manufactures bend radius requirements.
13. Cabling shall be routed in metallic conduit to box (located at required height) concealed in new wall construction.
14. Group and tie-wrap all cabling in a neat and orderly manner with Velcro cable ties for observation during above ceiling punch list or other walk-through. Remove ties after approval by Engineer.
15. Install cabling in pathways/raceways without exceeding EIA/TIA maximum fill for that raceway type.
   a. Install cabling in conduits/sleeves to the maximum fill capacity allowed before using an adjacent conduit/sleeve when multiple conduits/sleeves are required.
   b. Install all exposed cabling penetrating walls or through floors through rigid metallic conduit/sleeves or Fire Rated Assembly.
   c. Refer to Division 26 Section "Conduit Rough-In Systems" for conduit/sleeve requirements.
16. Route cabling to avoid elevator shafts, elevator equipment rooms or any areas that contain or store hazardous materials.

17. Avoid sources of electromagnetic interface (EMI) for all voice/data equipment and cables.
   a. Maintain 5" minimum from lighting ballast.
   b. Maintain 4 foot minimum from all transformers.
   c. Maintain 1 foot minimum from electric power conductors.
   d. Distances may be reduced if sufficient EMI isolation is provided and prior approval is given by the Engineer.

18. Avoid routing cabling in areas subject to excessive environmental conditions.
   a. Refer to Division 26 Section "Conduit Rough-In Systems" for environmental requirements.

19. Replace entirely any cable jacket that is cut or scored during installation.
20. Terminate all cabling at each cable end as indicated in these specifications.
21. Test cabling as indicated in these specifications.
22. Label cabling as indicated in these specifications.
23. Do not "comb" the cables but leave them placed in a random fashion as cables running parallel could affect high frequency transmission.

B. Adjust and balance all circuits as specified herein. Set all controls and software parameters to render a fully and optimally operating systems and subsystems. All computer-controlled functions shall require complete audio/computer/software setup, balancing, label-entry and documentation.

C. The Contractor shall provide suitable filters, traps, and pads for minimizing interference and for balancing the amplifiers and distribution system(s). Items used for balancing and minimizing interference shall be able to pass video, audio, data, and control signals in the speeds and frequency bands selected, in the directions specified, with low loss and high isolation. The Contractor shall install all equipment necessary to meet the requirements each system's performance standards.

D. All passive equipment shall be connected according to the original equipment manufacturer's specifications to insure correct termination, isolation, impedance match, and signal level balance.

E. Provide system so that the installation, integration, and combination of equipment actually employed does not produce any undesirable audible effects such as signal distortion, noise pulses, glitches, audio hum, poling noise, voltage or spike transients, etc.

F. Provide noise filters and surge protectors for the audio system including cabling, equipment racks and display devices to ensure protection from input primary AC power surges and noise glitches are not induced into low voltage data circuits.

G. Provide all signal regeneration equipment as required to ensure all system outputs are clear and level for processing by display equipment.

H. Provide additional branch circuits and power connections to equipment as required. Include and indicate additional power requirements on wiring diagrams at submittal stage for coordination with other Divisions and approval by Engineer.
3.5 EQUIPMENT INSTALLATION

A. Mount all equipment in furniture.

B. Install systems and components, in accordance with equipment manufacturer’s written instructions, in compliance with recognized industry practices, to ensure that the sound system complies with requirements and serves intended purposes.

C. Install equipment properly to avoid causing mechanical stresses, twisting or misalignment of equipment being exerted by clamps, supports, and cabling.

D. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer’s published torque tightening values for equipment connectors. Where manufacturer’s torque requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B, and the National Electrical Code.

E. Remove all dirt, dust and construction debris from all system equipment. Touch-up scratched and marred surfaces to match original finishes to the satisfaction of the Owner/Engineer.

F. Identify, initiate, coordinate and complete all required programming of all equipment for proper and safe operation of equipment and users.

G. Properly test all equipment for proper operation and provide final adjustments as required for optimal audio performance.

H. Provide all equipment test reports, signed and certified to Owner and Engineer prior to substantial completion.

I. Trim and Escutcheon Components:
   1. To insure a proper finished appearance, the AV Contractor shall furnish and install trim/escutcheon components at all conditions where AV components pass through the finished ceilings. This would include but not be limited to any component which is not specifically supplied with integral flanges/trim components; i.e. speaker mount.
   2. The visible component of any trim should be minimal in size, preferably no wider than 1/2". All trim components at the ceiling plane shall be finished to match the approved ACT ceiling grid system components. The audio visual contractor should obtain a sample from the Generator Contractor, including any custom color information, or standard color numbers. All trim components shall be submitted to the Architect for review and approval prior to fabrication.

3.6 DIGITAL SIGNAL PROCESSOR INSTALLATION

A. Configuration:
   1. Provide inputs and outputs as shown on the drawings and identified in the specifications to meet the requirements intended.
   2. Cascade and link units as required to accommodate inputs and outputs for integration and control.
   3. Coordinate programming with media controller and A/V switcher inputs.
   4. Customize equalizer configuration to the rooms environment including but not limited to tone controls, compressors, limiters, levelers, gates, delays and other devices as recommended by manufacturer.

3.7 EQUIPMENT CABINET INSTALLATION

A. Provide rough-in and pathways to conceal all cabling entering the equipment cabinets.
B. Mount equipment cabinets to equipment backboxes providing rigidity to support all equipment and allow accessibility to rack.

C. Mount cabinets to allow access to chases, sleeves or slots for cable routing to equipment and devices.

D. Install ground lug and attach ground conductor per Division 26 Section "Grounding and Bonding for Electrical Systems" and as recommended by manufacturer.

3.8 LOUDSPEAKER INSTALLATION

A. The following general minimum standard requirements shall be applicable to the fabrication and installation of all loudspeaker(s) and loudspeaker assemblies in the Project.

1. Provide all rigging/mounting brackets and tile bridges for speakers. Provide positioning for loudspeaker assemblies wherever required.
2. Coordinate installation of all loudspeaker assemblies and baffles to ensure proper projection of the respective loudspeaker elements, and access to them for maintenance and/or removal.
3. Verify that no loudspeaker assembly is subjected to stress, abrasion or loading effects which could contribute to extraordinary failure.
4. Eliminate all conditions causing noise, rattle, or other extraneous sounds resulting from the operation of a loudspeaker assembly under any operating condition.
5. Verify that baffle openings and loudspeaker components are clear of paint, and/or any other obstructions.
6. Connect all loudspeaker assemblies to the appropriate 70-volt line transformer tap to realize specified sound pressure levels and ensure uniform polarities of loudspeaker elements.

3.9 LABELING

A. Provide at equipment (cabinet), device and outlet as required.

B. All cables, regardless of length, shall be marked with a permanent, self-laminating wrap-around number or letter cable marker at both ends, similar to the Panduit "Pan-Code" system. Labels must be computer-generated for legibility. Wire labels done by hand in the field must be replaced with computer generated labels. There shall be no unmarked cables at any place in the system. Marking codes used on cables shall correspond to codes shown on Drawings and or run sheets.

C. Machine Printed Labels:

1. Self adhesive, smudge resistant vinyl labels for cables and faceplates.
2. Size labels appropriately for cable diameters; utilize "wrap" installation.
3. Size labels appropriately to fit in recessed area of faceplate, under available plastic cover or at proper location to identify control buttons or inputs.
4. Submit samples of labels to verify color of label and size of font for each application.
5. Center justify all text.
6. Utilize Hellermon-Tyton Spirit 2100 or approved equal by Rhino Pro, Brother, or Panduit.
7. Engrave faceplates for A/V outlets with input type or provide factory provided (non-removable) markings acceptable to Owner and Engineer.

D. Provide labels at all equipment controls requiring user interface for Owner troubleshooting and easy identification for future re-programming or configuration.

E. Labels shall be affixed free of smudges and fingerprints within three inches of termination.

F. Labels shall be viewable without rotating or removing patch cords or cables.
3.10 CABLE INSTALLATION

A. All wire bundles are to be neat and combed free of cable crossovers.

B. All cables shall be grouped according to the signals being carried. In order to reduce signal contamination, separate groups shall be formed for the following cable families:
   1. Power cables.
   2. Control cables.
   3. Video cables.
   4. Audio cables carrying signals less than 20 dBm.
   5. Audio cables carrying signals between –20 dBm and +20 dBm.
   6. Audio cables carrying signals above +20 dBm.

C. As a general practice, all power cables, control cables, and high level cables shall be run on the left side of an equipment rack as viewed from the rear. All other cables shall be run on the right side of an equipment rack, as viewed from the rear.

D. Cable ties shall be placed at appropriate intervals of no greater than six inches for vertical bundles, two inches for horizontal bundles.

E. All cables shall be continuous lengths without splices. All system wire, after being cut and stripped, shall have the wire strands twisted back to their original lay and be terminated by approved soldered or mechanical means. Except where noted otherwise in the specifications, NO BARE WIRE TERMINATIONS WILL BE ACCEPTED. Heat-shrink tubing shall be used to insulate the ground or drain wire. Unused wires at the end of a cable shall remain unstrapped and shall be laid back and held in place with wire ties.

F. All solder connections shall be made with rosin-core solder using temperature-controlled solder stations. Care shall be taken to avoid cold or cracked solder joints. Any connections that do not appear to be clean and shiny, or which show signs of cracking, shall be resoldered by the Contractor before final acceptance of the system.

G. Mechanical connections using insulated, crimp-type connectors shall be bonded to the connector by soldering the wire to the metal part of the connector.

H. Connections made with screw actuated pressure type terminal strips shall be made by stripping approximately 1/4 inch of insulation from the stranded conductor. Then the untinned wire shall be inserted into the terminal and the screw tightened using a secure fitting precision screwdriver.

I. Terminal blocks, boards, strips, or connectors shall be furnished for all cables which interface with racks, cabinets, consoles, or equipment modules. No audio cables shall run directly to the audio patch panel jacks. Each audio patch panel shall be furnished with an audio terminal block, and all audio cables to and from the audio patch panel shall terminate on this block.

J. All wire markers shall face a common direction.

K. All cables shall have proper connector housing.

L. Cables shall not protrude from the back of racks.

M. All cable entry shall be through the tops of racks or through entrance holes in the base of the rack. No cable shall enter racks through front, rear or side panel openings.

N. All cables (except video and pulse cables, which must be cut to an electrical length) shall be cut to the length dictated by the run. No splices shall be permitted in any pull boxes without prior permission of the Owner’s Representative. For equipment mounted in drawers or on slides, the interconnecting cables shall be provided with a service loop of appropriate length.
O. No cable shall be installed with a bend radius less than that recommended by the cable manufacturer.

P. Where cables are installed in architectural niches, ensure that the cables are black, unless otherwise directed, to reduce visibility from the audience.

Q. Wires and cables shall be insulated to prevent contact with signal or current carrying conductors and 100% shielded. Wires or cables used in assembling consoles, panels, equipment cabinets and racks shall be formed into harnesses that are bundled and tied. Harnessed wires or cables shall be combed straight, formed, and dressed in either a vertical or horizontal relationship to equipment, controls, components or terminations.

R. Harnesses with intertwined members are not acceptable. Each wire or cable that breaks out from a harness for connection or termination. Tie off at that harness or bundle point, and be provided with an ample neatly formed service loop.

S. Provide system input and output polarity as recommended by the original equipment manufacturer. Ensure each color-coded wire or cable is connected and terminated to maintain system polarity to be at least the same quality of professional audio systems. Reflect all color codes, wire and cable terminations on the system's Drawings of Record as required herein.

3.11 CLEANING

A. Clean all equipment on a day-to-day basis and final cleaning of all equipment prior to turning over to the Owner. Clean to the satisfaction of the Owner’s representative.

B. Equipment:
   1. Clean all equipment completely inside and out prior to testing.
   2. Furnish cleaning consisting of vacuuming all panels, terminations, enclosures (inside and out), etc. Thoroughly dry wet equipment or if contains moisture before testing.

C. Raceways and Junction Boxes:
   1. Blow out and dry all raceways and conduits prior to installation of cabling.

3.12 CLOSE OUT ACTIVITIES

A. Field Quality Control:
   1. Wiring Methods:
      a. Install wiring in raceways except within lecterns, desks, racks, and except in accessible ceiling spaces, where open cable wiring methods may be used. Use UL-listed plenum cable.
      b. Install cabling in raceways in all areas with exposed structure.
      c. Conceal all exposed furniture wiring in approved cable enclosure to make inconspicuous.
      d. Cable shall be homerun per manufacturer’s specifications.
      e. Control Circuit Wiring: Provide number of conductors as recommended by system manufacturer to provide control functions indicated, specified or to meet design intent.
      f. Install cables and raceways parallel and perpendicular to surfaces or exposed structural members, and follow surface contours. Secure and support cables/conduits by straps or similar fittings so designed and installed as not to damage the cables. Secure cable at intervals not exceeding 30 inches and not more than 6 inches from every cabinet, box, or fitting.
g. Wiring within Enclosures: Provide adequate length of conductors to allow sliding cabinet to open and rotate 90 degrees. Bundle, lace, and train the conductors to terminal points with no excess. Provide and use lacing bars.

h. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes, terminal cabinets, and equipment enclosures.

i. Identification of Conductors and Cables: Use color coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with system wiring diagrams.

j. Provide physical isolation from each other for microphone, line level, speaker, and power wiring. Run in separate raceways or provide 12-inch minimum separation where exposed or in same enclosure. Provide additional physical separation as recommended by equipment manufacturer.

B. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

C. Manufacturer’s Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the pretesting, testing, and adjustment of the system.

D. Before final acceptance of the system, manufacturer-supplier of system shall, in presence of Owner’s representative, test each and every component and device in the system. Test shall be documented with signed copy submitted to the Owner and Architect/Engineer.

E. The system shall be physically inspected by the Owner’s representative and the Architect/Engineer to assure that all equipment is installed in a neat and workmanlike manner as called for in the plans and specifications.

F. Upon completion of the system installation, and after circuitry has been energized with the normal power source, test the system to verify the following:
   1. All components are operational and functioning properly to the system designs intent.
   2. Perform all necessary adjustments and balancing of all signal and amplifier level controls to insure proper operation. Ensure output levels of sources are equal.
   3. The complete system is free from grounds, open and shorts except for made grounds required by the system installation.
   4. The system is free of hum or noise including but not limited to ground loops, improper impedance matching or improper shielding.
   5. Configure signal processor to perform all gating, precedence, equalization and compression to provide optimal performance.
   6. Correct all of the above and retest to demonstrate compliance where required by Engineer.
   7. All testing shall be documented. Provide a signed copy to the Owner/Engineer verifying the system is complete, and fully functional.
   8. Make observations to verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

G. Contractor System Checkout:
   1. Before acceptance tests are schedule, perform system checkout based upon an approved testing procedure for the systems. Contractor to furnish all required test equipment and perform all work necessary to determine and/or modify performance of the system to meet the requirements of this specification. Submit testing system for approval from the Owner’s Representative. The following is an example test procedure:
H. Check all control functions, from all controlling devices to all controlled devices, for proper operations.

I. Maintain documentation of all performance tests for reference by the Owner’s Representative during the System Acceptance Tests.

J. System Acceptance Tests:
   1. System Acceptance Tests will not be performed until the Contractor’s System Checkout has been completed and the test results have been reviewed. The System Acceptance Tests will be supervised by the Owner’s Representative and will consist of the following:
      a. A physical inventory will be taken of all equipment on site and will be compared to equipment lists in the contract documents.
      b. The operation of all system equipment shall be demonstrated by the Contractor.
      c. Both subjective and objective tests will be required by the Owner’s Representative to determine compliance with the specifications. The Contractor shall be responsible for providing test equipment for these tests.
      d. All final “as-built” drawings, run sheets, manuals, and other required documents, as detailed in the previous section, shall be on hand.
      e. In the event further adjustment is required, or defective equipment must be repaired or replaced, tests may be suspended or continued at the option of the Owner’s Representative.

K. Occupancy Adjustments:
   1. When requested by the Architect, within one (1) year of date of substantial completion, provide on-site assistance in re-programming systems to suit user operation and actual, occupied conditions.
   2. Provide up to three (3) visits for this work.

L. Test Equipment:
   1. Each Contractor is responsible for furnishing all test equipment required to test the system in accordance with the parameters specified. Unless otherwise stated, the test equipment shall not be considered part of the system. Each Contractor shall furnish test equipment of accuracy better than the parameters to be tested.
   2. The test equipment furnished by each Contractor shall have a calibration tag of an acceptable calibration service dated not more than 12 months prior to the test. As part of the submittal, a test equipment list shall be furnished that includes the make and model number of the following type of equipment as a minimum:
      a. Oscilloscope.
      b. Spectrum Analyzer.
      c. Signal Level Meter.
      d. Volt-Ohm Meter.
      e. SPL Meter.
      f. SPL Calibrator.
      g. Sine wave and random Noise Generator.
      h. Audio Amplifier with external speaker.

M. Record cable runway locations and sizes onto project blue prints.
   1. Record sizes of pathways, location of cable routings and system rack elevations as installed on the project blueprints.
   2. Submit as-built documents for Engineer's review and approval.
N. Owner's Instructions:
   1. Operation and Maintenance Data: Provide approved shop drawings with modifications as
      required by engineer's instructions or project progression. Include operating and
      maintenance instructions, parts inventory listing, purchase source listing, emergency
      instructions, assembly/disassembly and termination diagrams, and wire administration
      data as specified herein.
   2. Provide any additional information as required per the manufacturer's requirements for
      required warranties.

O. Software Documentation:
   1. Actual source code must be provided. The software developer shall retain intellectual
      property rights to the operation software. The Owner shall be granted a license in
      perpetuity for use. Include the following:
      a. All source code becomes the exclusive property of Owner.
      b. All source code changes must be fully documented.
      c. All custom programs for remote control system touch panels, and other programmed
         devices are the property of the Owner, and be submitted with the final systems
         documentation via fileshare. Include a copy of the current program with the "as-
         built" drawings, in a magnetically protective envelope.
      d. Subsequent to system certification, implement source code changes and/or
         additional programming, warranty changes by the vendor for a period of one (1)
         year, with the vendor responsible for the diagnosis and repair. Ensure that the
         current program is saved and stored as outlined above.

P. Training:
   1. Furnish the services of a factory-trained engineer or technician for one (1) 1-hour periods
      to instruct the Owner's personnel. Include corrective and preventive maintenance of each
      system's equipment. Schedule training at the convenience of the Owner.

3.13 TURNOVER MEETING

A. Meeting:
   1. Upon completion of all work, coordinate a meeting with the Owner and Owner's
      Representative at the site to provide all as-built documentation, certifications, test reports,
      spare parts, and additional manuals, etc. Turn over prior to completion of final punch list.
   2. Provide in-depth review of all documentation and equipment to Owner for acceptance.

END OF SECTION 274118
SECTION 275113 - PUBLIC ADDRESS SYSTEM

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Health Care Facility:
   1. Provide a complete Public Address System including amplifiers, switches, source equipment, speaker assemblies, cabling, etc. for a fully operational Public Address System.

B. Requirements of Division 20 Section "Common Work Results, Divisions 21 through 28" apply to this Section.

C. Coordinate all work with Division 26 for proper pathways and rough-in requirements.

D. Refer to applicable Division 26 Sections for raceways, electrical boxes and fittings, and wiring/cabling required in conjunction with installation of Public Address System with Integral Master Clock.

E. Requirements of the following Division 26 Sections apply to this Section:
   1. Section "Common Work Results for Electrical."
   2. Section "Raceways" for raceways used or public address system cables."

F. Requirements of the following Division 27 sections apply to this section:
   1. Section "Common Work Results for Communications."
   2. Section "Structured Telecommunication Cabling Systems."
   3. Section "Telephone System."

1.2 SUMMARY

A. This Section includes public address systems. It includes requirements for public address system components including, but not limited to, the following:
   1. Mixer/Amplifier
   2. Speakers.
   3. Wiring.
   4. Telephone Paging Adapters.

1.3 SYSTEM DESCRIPTION

A. General: The public address system shall be a complete system for amplifying sound signals from telephone system and program sources and distributing them to loudspeakers at various locations.

B. Functional Performance: Components and system features and functions shall include, but are not limited to, the following:
   1. All-Call Operation: Single switch control to make an announcement to all speaker stations simultaneously, regardless of zone or channel switch settings.
   2. Telephone Paging: Ability to use the all-call function or zone call function by dialing an extension from any local telephone instrument and speaking into the telephone.
   3. High-Quality Sound Reproduction: Freedom from noises such as pops, clicks, hiss and hum at all loudspeakers at all times during operation of the system, including standby mode with inputs off. Freedom from distortion and non-uniform coverage of amplified sound.
C. Provide new-speakers and cabling in the new addition and connect into the new system. Re-work existing cabling, speakers into new system.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections, and Division 27 Section "Common Work Results for Communications."

B. Submittals shall be provided based on specification number and be inclusive of the equipment within that section. Equipment submitted from multiple sections under a single cover, will not be reviewed.
   1. Provide six (6) copies of all submittal information for review.
   2. Provide electronic copy of all submittal information in PDF Format/Microsoft Word/Excel Format.

1.5 ACTION SUBMITTALS

A. Product Data: Submit for each type of product specified.
   1. Provide manufacturer’s literature to include all information necessary to confirm that the proposed system is in complete compliance with the Specifications.
   2. Provide all information in a single, complete bound submission.
   3. Table of Contents identifying equipment lists with numbered pages corresponding to equipment/device locations within submittal for quick reference.
   4. System Scope of Work narrative including Owner meetings, Owner reviews, programming approval, milestones, and testing.
   5. Equipment Information:
      a. All equipment shall be specific to this section only unless required for integration.
         1) Manufacturer’s specifications and descriptive literature.
         2) Manufacturer’s recommended installation procedures.
         3) Equipment/device quantities.
         4) Equipment/device product information sheets with submission designated, installation information, color/finish options, etc.
         5) Program information sheets.
         6) Coordination requirements with all trades.
         7) Program layout diagrams, riser diagrams, wiring diagrams, rack elevations, seismic requirements, etc. Utilize Architectural, Electrical, and Communication symbology to be consistent with Owner's standards.
         8) Deviations from specifications, if any, highlighted with specific explanation and identification requiring Architect/Engineer specific approval.
         9) Manufacturer required information for base and extended warranties including submission requirements and timeframes.
        10) Estimated equipment heat loads and power requirements. List and tabulate equipment specifically required in Telecommunications Rooms and Equipment Rooms.
        11) Submit qualifications based on quality assurance requirements for manufacturer, supplier, installer, trainer, etc.
        12) Training outline.
        13) Sample test reports.
b. Provide a list with references of at least three (3) installations of equivalent or larger systems installed within the last two (2) years

1) Provide Facility location and name.
2) Owner’s or User’s name, address, and telephone (including fax) numbers.
3) Date of Project Start and Date of Final Acceptance by Owner.
4) System Project Number.
5) Brief (three paragraphs minimum) description of each system’s function, operation, and installation.

c. Provide certification with data substantiating that products comply with requirements of the Contract Documents. Furnish UL File number with product data as submitted.

B. Certification Letter: Provide certification letter in lieu of submittal. Refer to Division 01 requirements for procedure.

C. Shop Drawings (Submit for each):
   1. Layout Drawings:
      a. Submit scaled system layout drawings using architectural floor plans indicating head end equipment layout and dimensions. Include layout of equipment in relation to room size and other existing and new system equipment in that room. Include equipment layout and rack elevations.
         1) Indicate connections to equipment supplied by others.
      b. Submit scaled system layout drawings using architectural floor plans for system equipment indicating cable types, amplifiers, electrical connections, taps, etc., as designed for this project.
         1) Include tap values, db levels and other important system configuration values.
         2) Include lengths of all trunk cables, feeder cables, and horizontal cables.
         3) Provide building room numbers and diagrams specific to this project.
         4) All panels, plates and designation strips, including details relating to terminology, engraving, finish and color.
         5) Detailed wiring for connectivity of other interfaces. Differentiate clearly intersystem connections.
         6) Wiring Diagrams detailing wiring for power, signal, and control differentiating clearly between manufacturer-installed wiring and field-installed wiring. Identify terminal numbers and wiring color codes to facilitate installation, operation, and maintenance.
         7) Front mechanical drawings of each equipment rack.
         8) Cable labeling plan.
         9) Grounding: Identify grounding requirements and connections to Telecommunications Grounding Busbar.
         10) Differentiate between portions of equipment that are factory/vendor assembled and that which are field-installed.
   2. Software and Schedules:
      a. Programming:
   3. Factory Quality Control Test Reports:
      a. Warranty and service agreement.
D. Coordination Drawings (1):
   1. Details of system including but not limited to the following:
      a. Rack arrangements.
      b. Interface method to other systems or equipment.
   2. Integration: Detail interconnections to other systems.

E. Samples:
   1. Factory Samples:
      a. For verification: For each type of termination indicated.
   2. Field Samples (1):
      b. Labeling: Provide label samples and method including a complete cable "Runlist" of cabling required on the project.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. Source Quality Control Reports:
      a. Submit factory test report from each reel of preterminated cable.
   2. Special Warranty:
      a. All items of equipment must be new, in current production, currently eligible for warranty and maintenance coverage and have guaranteed availability for a minimum of five (5) years from the Substantial Completion date.
   3. Supplier Qualifications:
      a. Certification signed by officer of installation company attesting that proposed system complies with specification requirements:
         1) For multiple firms, an officer from each firm must sign.
   4. Installer Qualifications:
      a. Provide documentation of certification of manufacturer, supplier, installers, Project Managers and instructors to be utilized on this project. Documentation to include the following:
         1) Manufacturer Training and Certifications:
            a) Submit contractual relationship or technical certification by the respective equipment manufacturers that installer is authorized by that equipment manufacturer to pass through the manufacturer's certification and equipment warranty to the Owner. Additionally, the equipment manufacturer and Contractor shall accept complete responsibility for the design, installation, certification, operation and physical support for the system.
         2) Industry Training and Certifications:
a) The Audio Visual Technicians assigned to the system shall be fully trained, qualified, and carry valid and current industry certifications regarding the Engineering, installation, operation, and testing of audio visual technologies. At least one (1) each InfoComm International CTS-D and InfoComm International CTS-I or equal certifications by NSCA shall be assigned to oversee the complete design and installation of the system. The Contractor shall provide formal written evidence of current industry certification for the designer(s) and installer(s) dedicated to this project as a part of their submittal before being allowed to commence work on the system. Certifications of employees assigned to the project shall be local to the project site. If subcontracting a portion of the work subcontractor shall have the same certifications and be local to the job site.

b) Company and its subcontractor shall be InfoComm APEx certified member.

b. Provide reference list of at least five similar installations successfully completed within the last three years within a 100 mile radius. Include scope of work, contact name, title and telephone number.

c. Project Manager Resume’.

5. Manufacturer’s Instructions:
   a. Manufacturer’s recommendations for installing
   b. Provide documentation of certification of manufacturer, supplier, installers and instructors to be utilized on this project.


B. Coordination Data:
   1. Coordination Drawings:
      a. Provide trade coordination drawings of corridor ceilings with limited space where congestion with other systems may be a problem.

C. Field Quality Control Test Reports:
   1. Field Test Reports.

1.7 CLOSEOUT SUBMITTALS
A. Operations and Maintenance Data:
   1. Final Submittal Copy:
      a. Approved copy of system submittal.
      b. Provide a listing of individual product/device/equipment warranties provided from the manufacturer with expiration dates identified.
      c. Provide a complete listing of devices, installed locations with product serial numbers for product tracking.
      d. Provide all equipment and device licensing information equal to the lifetime of the product with the current system integration.
      e. Provide a complete set of equipment cut sheets, parts list, including maintenance criteria, “troubleshooting” guide, distributor information and service information for all equipment provided.
f. Provide a complete set of instruction manuals; including complete written programming instructions, programming documentation and system set-up documentation.  

1) Provide an additional quick-start guide with all commonly used procedures for operating the system. Laminate and provide copies during training session.

g. Provide all test results performed. Include manufacturer's certifications that installed system complies with specification requirements.

2. Special Warranty Information:
   a. Provide copy of all documentation including test results sent to manufacturer for system warranty.
   b. Provide all required documentation to the system manufacturer to initiate and ascertain the warranty specified.
   c. Provide warranty of the system by the system manufacturer and guaranteed for the term of the warranty.

3. Service Contract:
   a. Provide copy of first service contract terms for Owner evaluation prior to accepting or rejecting service contract.

B. Record Documents:

1. Operation and Maintenance Data:
   a. Include the following in emergency, operation and maintenance manuals.
      1) Three (3) final corrected copies of catalog data and shop drawings, critical spare parts lists, and manufacturer's operation and maintenance data applicable for the equipment furnished.
      2) Instructions for periodic testing.
      3) Warranty information.

   b. Provide documentation identifying EDID information for all devices and components.

2. Record Drawings:
   a. Record drawing indicating locations of all system components.
   b. Provide a revised set of system wiring diagrams upon the completion of the installation for subsequent testing of the system to show actual cable routing, connections with other systems, cable lengths values of all equipment as installed and actual signal values as tested.
   c. Utilize architectural floor plans for system layout.

3. Training / Demonstration Video.

4. Final Field Quality Control Test Reports:
   a. Test report indicating compliance with performance requirements for signal level, system response and signal-to-noise ratio.

1.8 QUALITY ASSURANCE

A. Manufacturer's Qualifications:

1. Firms regularly engaged in manufacture of professional quality public address systems, components and accessories, of types, capacities and characteristics required, whose products have been in satisfactory use in similar service for not less than two (2) years.
B. Supplier’s Qualifications:
   1. Engage an experienced product supplier who is a factory-authorized sales and service representative regularly engaged in the design and installation of such systems to oversee the installation, trouble-shoot and make final connections at headend equipment.
   2. Supplier shall have represented the product and components being installed for a minimum of five (5) years.

C. Installer Qualifications:
   1. Firm with at least five (5) years of successful installation experience with projects installing public address sound systems equipment similar to that required for this project.
   2. Refer to Division 01 Section "Definitions and Standards" for definition of experienced Installer. Upon request submit evidence of such qualifications to the Architect/Engineer.

D. Electrical Component Standard: Provide work complying with applicable requirements of NFPA 70 "National Electrical Code."

E. All system and components shall be Underwriters Laboratories listed and labeled.

F. EIA Compliance: Comply with the following Electronics Industries Association Standards:
   2. Loudspeaker, Dynamic Magnetic Structures, and Impedance, EIA-299-A.
   3. Racks, Panels, and Associated Equipment, EIA-310-A.
   5. Speakers for Sound Equipment, SE-103.
   6. UL Compliance: Comply with requirements of UL 50.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements:
   1. Deliver components properly packaged in factory fabricated containers.
   2. Deliver reels, racks, etc. on truck with hydraulic gate or lower carefully using hoist or fork lift. Never drop equipment.
   3. Upended heavy equipment, racks, reels, etc. will often arrive damaged. Refuse or receive subject to inspection for hidden damages. Records of delivery date, manufacturer, installation date, any extenuating circumstances along with manufacturer test reports shall be kept on file.

B. Storage and Handling Requirements:
   1. Store components in original cartons.
   2. Material shall be stored in a secure area with a clean dry space protected from the effects of the weather and away from open fires or sources of heat.
   3. Material shall be stored in an area away from construction traffic where construction equipment, falling or flying objects or other materials will not contact the components.
   4. Material shall be stored in an area where chemicals, paint, or petroleum products will not be spilled or sprayed on them.
   5. Cable reels must remain in the upright position. Cable reels must not be stored on their sides. Reels must not be stacked.
   6. Cable reels and lagging must not be stored sitting in direct contact with water or dampness. Reels should be stored on flat, hard surface so that flanges do not sink into the earth. Timbers or metal supports must be placed under the red flanges to provide elevated storage away from water or damp soil.
7. Reels can be hoisted with a shaft extending through both flanges or cradle both reel flanges between fork lift forks. Never allow forks to touch cable surface or reel wrap. Do not lift by top flange.

8. Handle equipment and components carefully to avoid breakages, impacts, denting and scoring finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer. Store components in original cartons.

9. If materials are relocated, an inspection shall be made.

10. Handle equipment and components carefully to avoid breakages, impacts, denting and scoring finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer.

C. Packaging Waste Management:
1. Dispose of all packing materials and include cost of packing materials disposal and handling as part of the base bid.

1.10 WARRANTY

A. Contractor Construction Warranty:
1. Refer to Division 01 requirements.

B. System Warranty:
1. Provide a warranty for the entire system.
2. The warranty shall be backed by the manufacturer’s certified vendor.
3. In the event that the system is being interfaced to existing equipment, that equipment warranty shall be covered by the new warranty implemented with this project.
4. Warranty shall commence when the following construction milestones are met:
   a. Substantial Completion.
   b. Final Engineer acceptance of complete system installation.

C. Special Warranties: Manufacturer specific product/equipment warranties beyond that listed as system operation.
1. Provide a 5 year manufacturer warranty. This warranty will cover all electronic equipment.

D. EIA Compliance: Comply with the following Electronics Industries Association Standards:
2. Loudspeaker, Dynamic Magnetic Structures, and Impedance, EIA-299-A.
5. UL Compliance: Comply with requirements of UL 50.

1.11 LICENSES

A. Provide all licenses for all equipment to operate for the lifetime of the installed equipment and system.
1. Licenses shall not expire for the equipment or devices purchased and installed and shall not be required for extending maintenance or operation of the system.
2. Licenses shall cover software and hardware.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Bogen.

2.2 SYSTEM OPERATION

A. The platform shall provide the ability to initiate safety paging announcements, from any telephone within the facility or outside the facility.

B. Audio Paging Mixer/Amplifiers:
   1. Power amplifier(s) shall be provided to provide a minimum of 2 watts of power to all paging speakers, and 15 watts of power to all paging horns.
   2. The maximum load on the paging/program amplifiers shall be 80% of the rated maximum output of the amplifiers.
   3. Manufacturer:
      a. Bogen GS150D

2.3 PERIPHERAL EQUIPMENT

A. Ceiling Speaker Assembly; Flush Mounted:
   1. Cone-Type Loudspeakers – (Corridors):
      a. 8" dual cone speaker.
      b. 25V/70V line matching transformer.
      c. Five (5) tap settings; 5/16, 5/8, 1-1/4, 2-2/1, 5 watts.
      d. 10 ounce ceramic magnet.
      e. 15 watts RMS power rating.
      f. 60-16000 Hz frequency response.
      g. Manufacturer shall be Bogen S86T725.
   2. Flush Mount Ceiling Baffle:
      a. White baked enamel finish. White
      b. 22-gauge steel.
      c. Round, 12-7/8" diameter; for mounting 8" dual cove speaker.
      d. Bogen #PG8W.
   3. Speaker/Baffle Support Bridge:
      a. Universal speaker mounting to eliminate ceiling tile sag.
      b. 2’ x 2’ or 2’ x 4’ tile support.
      c. All-steel construction.
      d. Bogen #TB8

B. Paging Speaker – Horn; Indoor:
   1. Paging – Talkback speaker.
   2. 14 watt RMS power rating.
   3. Weatherproof heavy duty construction.
   4. 272 – 13,000 Hz integral driver.

PUBLIC ADDRESS SYSTEM

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5. 25V/70V line matching transformer.
6. Manufacturer shall be Bogen #PA15TA.

C. Paging Speaker-Horn; Outdoor:
1. Durable waterproof construction.
2. 30 watt RMS power rating.
3. 225-13,000 Hz integral driver.
4. 25V/70V line matching transformer.
5. Manufacturer shall be Bogen #PA15TA.

D. Wire and Cable:
1. Conductors:
   a. Size speaker circuit conductors from racks to loudspeaker outlets not smaller than 18 gage and conductors from microphone receptacles to amplifiers not smaller than 22 gage. Use jacketed twisted-pair untinned solid copper conductors.
   b. Manufacturer:
      1) Belden 6300FE

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine conditions, with the Installer present, for compliance with requirements and other conditions affecting the performance of the Public Address system work.
B. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. General: Install system in accordance with NFPA 70 and other applicable codes. Install equipment in accordance with manufacturer's recommendations and written instructions.
B. Wiring Methods: Install wiring in raceway except within consoles, desks, and counters, and except in accessible ceiling spaces, where open cable wiring method may be used. Use UL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal wiring.
   1. Provide separate pathway for sound system cabling from other electrical systems. Do not run clock cabling in close proximity to telecommunications cabling. Route cabling parallel and perpendicular to surfaces or exposed structural members, and follow surface contours. Secure and support cables by straps or similar fittings so designed and installed as not to damage the cables. Secure cable at intervals not exceeding 30 inches and not more than 6 inches from every cabinet, box, or fitting.
   2. Cabling shall be installed in conduit in exposed areas. Route conduit above structural steel to best conceal conduit.
C. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
D. Wiring Within Enclosures: Provide adequate length of conductors. Bundle, lace, and train the conductors to terminal points with no excess. Provide and use lacing bars.
E. Provide physical isolation from each other for microphone, line level, speaker, and power wiring. Run in separate raceways or provide 12-inch minimum separation where exposed or in same enclosure. Provide additional physical separation as recommended by equipment manufacturer.
F. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes, terminal cabinets, and equipment enclosures.

G. Identification of Conductors and Cables: Use color coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with system wiring diagrams.

H. Weatherproofing: Weatherproof units to be mounted out-of-doors or exposed to weather in any degree.

I. Repairs: Wherever walls, ceilings, floors, or other building finishes are cut for installation, repair, restore, and refinish to original appearance.

3.3 PROGRAMMING REQUIREMENTS

A. Manufacturers shall identify, initiate, coordinate and complete all required programming of the public address system.

3.4 GROUNDING

A. Provide equipment grounding connections for system as required. Terminate a minimum #2 ground conductor from all equipment cabinets to signal ground bar. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.

B. Ground equipment, conductor, and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the pre-testing, testing, and adjustment of the system.

B. Before final acceptance of the system, manufacturer-supplier of system shall, in presence of Electrical Contractor, Owner's representative, test each and every component and device in the system. Test shall be documented with signed copy submitted to the Electrical Contractor, Owner and Architect/Engineer.

C. The system shall be physically inspected by the Owner's representative and the Architect/Engineer to assure that all equipment is installed in a neat and workmanlike manner as called for in the plans and specifications.

3.6 SYSTEM TESTING, ADJUSTMENTS, AND CLEANING

A. Upon completion of the system installation, and after circuitry has been energized with the normal power source, the manufacturer/supplier shall test the system to verify the following:

1. All components are operational and functioning properly to the system designs intent.
2. Operational Test: Perform an operational system test to verify conformance of system to these Specifications. Perform tests that include originating program and page material at microphone outlets, all preamplifier program inputs, and all other inputs. Observe sound reproduction for proper volume levels and freedom from noise.
3. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1,000, 3,000, 8,000, and 12,000 Hz into each pre-amp channel and measure the distortion in the power amplifier output. The maximum distortion at any frequency is 3 percent total harmonics.

4. Power Output Test: Measure the electrical power output of each power amplifier at normal gain setting at 50, 1,000, and 12,000 Hz. The maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.

5. System Shutdown Test: Verify correction of all connected master and secondary clocks on the system after system has lost power.

6. Perform all necessary adjustment balancing of all signal and amplifier level controls to insure proper operation.

7. The complete system is free from grounds, open and shorts except for made grounds required by the system installation.

8. Correct all of the above and retest to demonstrate compliance where required by Engineer.

9. Make observations to verify that units and controls are properly labeled, and interconnecting wires and terminals are identified. Provide a list of final tap settings of speaker line matching transformers.

10. All testing shall be documented. Provide a signed copy to the Owner/Engineer verifying the system is complete and fully functional.

B. The manufacturer/supplier shall set all field adjustable components to optimize the system. Balance all signals, adjust and verify input voltages, current settings and frequency settings.

3.7 TRAINING

A. Provide on-site training on the use of the public address system to the Owner's selected personnel.

1. Provide a minimum of 4 hours of training to selected personnel. Training shall be completed in 1-hour increments. Training shall include programming, adjustment, troubleshooting, replacement of components and preventative maintenance of the system.

2. Schedule training with Owner through the Architect with at least seven (7) days advance notice.

3. Provide laminated instruction sheets to all users with all commonly used procedures for operating the system.

B. Occupancy Adjustments: When requested by the Architect within one (1) year of date of Substantial Completion, provide on-site assistance in reprogramming zones, individual room numbers, adjusting sound levels, resetting matching transformer taps, and adjusting controls to suit actual occupied conditions. Provide up to three (3) visits to the site for this purpose.

3.8 OPERATION AND MAINTENANCE MANUALS

A. Equipment Manuals:

1. Approved copy of system submittal.

2. Provide a complete set of equipment cut sheets, parts list, including maintenance criteria, "trouble-shooting" guide, distributor information and service information for all equipment provided.

3. Provide a complete set of instruction manuals; including complete written programming instructions, programming documentation and system set-up documentation.

   a. Provide an additional quick-start guide with all commonly used procedures for operating the system. Laminate and provide copies to all offices.
4. Provide all test results performed. Include manufacturer's certifications that installed system complies with specification requirements.

B. Equipment Drawings:
   1. Provide a revised set of system wiring diagrams upon the completion of the installation for subsequent testing of the system to show actual cable routing, connections with other system cable lengths, zone numbers, values of all equipment as installed and actual signal values as tested.
   2. Utilize architectural floor plans for system layout.

3.9 CLEANING AND PROTECTION
   A. Prior to final acceptance, clean system components and protect from damage and deterioration.

END OF SECTION 275113
SECTION 275223 – NURSE CALL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY
   A. Furnish and install all Nurse Call systems including all work incidental thereto as shown on Drawings and specified.
   B. Requirements of Division 27 Section "Basic Division 27 Requirements" apply to this Section.
   C. Requirements of the following Division 26 Sections apply to this Section:
      1. Section "Basic Division 26 Requirements."
      2. Section "Raceways."
      3. Section "Low Voltage Electrical Power Conductors and Cable."
      4. Section "Boxes and Cabinets."

1.2 SYSTEMS INCLUDED
   A. Visual nurse call systems.
   B. Network based audio/visual nurse call systems.
   C. Code blue visual nurse call systems.
   D. Existing nurse call systems.
   E. Nurse call systems network platform.

1.3 SUBMITTALS
   A. General: Submit the following in accordance with Division 27 Section "Basic Division 27 Requirements."

1.4 ACTION SUBMITTALS
   A. Shop Drawings:
      1. Submit complete manufacturer's information to demonstrate the submitted equipment meets all requirements of this specification.
      2. System one-line diagram.
      3. System operation narrative.
      4. Samples of individual units.
      5. Submit edited catalog data, specifications, and wiring diagrams, indexed by Drawing symbols, for each typical component, wire and cable. Include complete raceway and wiring diagrams for each system indicating the location of each device, the routing and sizes or raceways, system and device wiring, and color coding utilized.
         a. Include middleware necessary to connect to Owner's wireless telephone system for workflow signaling messaging.
      6. Submit Owner approved nameplate inscriptions or programmed identifications for system annunciators and master stations. Show individual sizes of each device indicating spare capacity provided.
      7. (Submit UPS and calculations to demonstrate capacity to meet specifications for PC type master stations and/or network electronics).
      8. Software, software updates, and specific site licensing criteria.
9. Coordination Drawings: Detail system components that fit, match, and line up with provisions made in equipment specified in other Sections or in separate contracts:
   a. Patient service columns.

10. Manufacturer Certificates: Signed by manufacturers certifying that nurse call equipment complies with requirements.

11. Installer Certificates: Signed by Manufacturer certifying that the installer has completed the necessary training and is certified and authorized in installing the particular system.

12. Warranty: Special warranty specified in this Section.

1.5 INFORMATIONAL SUBMITTALS

A. Field Tests Reports and Observations: Include record of final adjustments certified by Installer.

B. Operation and Maintenance Data: For nurse call equipment to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Operating instructions.
   2. Troubleshooting guide.
   3. Wiring diagrams and terminal identification.
   4. Equipment parts list.
   5. Product data for types and sizes of wires and cables used.

C. Warranty: Special warranty and software agreement specified in this Section.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representatives (minimum two) who are trained and approved for installation of units required for this Project.
   1. Service Agreements (submit for review subject to Owner approval):
      a. Emergency Service: Provided 24 hours a day. When a total or catastrophic failure of equipment is reported to installer, within 2 hours of notification, a service person will be on site. (An example of a catastrophic failure would be an equipment cabinet or rack failure, a nurse console failure, or an integrated system(s) failure(s)).
      b. Routine Service: Provided within 4 business hours (9 a.m. to 5 p.m., Monday through Friday, excluding holidays) of notification. When a minor failure of equipment is reported to installer, a service person will be on site within 24 hours of notification. (An example of a minor failure includes peripheral equipment such as control stations, entertainment speakers, corridor lights, pull-cord stations, etc., which normally affect only one patient or patient room.)
      c. To meet the above requirements, assure qualified installers are located within a 100 mile radius of the project locations.
   2. All technicians, project managers, and trainers shall have Network Certifications (i.e. Cisco or Microsoft).

B. Manufacturer Qualifications: A firm experienced in manufacturing equipment similar to that indicated for this Project and that maintains technical support services capable of providing user with training, parts, and emergency maintenance and repair with a 24-hour-maximum response time.

C. Source Limitations: Obtain nurse call equipment components through one source from a single manufacturer.
D. Electrical Components, Devices, and Accessories: Listed and labeled according to UL 1069 as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. References:
   1. Health Insurance Portability and Accountability Act (HIPAA).
   2. UL Standard 1069 – Hospital Signaling and Nurse Call System.
   3. NEC Article 725 – Class 1, 2 and 3 Signaling Circuits.
   4. NEC Article 800 – Communication Circuits.
   5. State Hospital Code/Joint Commission of Hospital – Nurses Call Requirements.
   6. FDA Certification.

1.7 COMPATIBILITY
A. All new nurse call systems and their associated components shall be of the same manufacturer's product line. Whenever possible, use alike components in different system types.
B. Components added to existing nurse call systems shall be compatible to the system and shall be of the original manufacturer.
C. All key switches and lockable devices shall be keyed alike whenever possible.
D. The technologies and/or methods of the specified manufacturers may differ when achieving similar performance.
   1. Provide additional devices as necessary to obtain intent. For example:
      a. Duty stations located above ceilings for zone dome light tone generation.
      b. Dome light located above ceiling for room wiring hub when dome light for room not requiring dome light (but needed for proper room device operation).
   2. Combined devices may be considered when shown on Drawings as multiple devices. For example:
      a. Patient station, code blue station, and staff emergency station combined under one faceplate. Exceptions:
         1) Individual patient or dual patient stations.
         2) When emergency call stations are shown on both sides of the bed for easy physical access.
         3) Confirm with Froedtert IT for each case for decision in written request. Email Froedtert IT at, FCHITClinicalApplications@froedtert.com, for confirmation.

1.8 GENERAL SYSTEMS REQUIREMENTS
A. All systems shall provide visual and audible classification of calls placed on the system from activated peripheral devices to central control devices associated with the system type. Visual indicators shall be provided to signal staff of individual room status.
B. Call Classification Types And Associated Actuating Devices:
   1. Code Blue Call - activated at code blue station.
   2. Staff Emergency Call - activated at staff emergency station, patient station when associated patient room staff register station is activated, and psychiatric room station when psychiatric key entrance switch is in call mode.
   3. Priority Call - activated at patient station handset when station placed in priority mode, toilet station and bath/shower station.
5. Personal Attention Call - activated at patient station handset when station placed in personal attention mode.
6. Normal Call - activated at patient station when station placed in normal mode.
7. Duty Call – activated at staff station and duty station.
8. Staff Call - activate at staff station.

C. Call/Status and work flow processing Priority levels, 1 as highest, and associated dome light visual announcement.

<table>
<thead>
<tr>
<th>Call/Status Type</th>
<th>Priority Level</th>
<th>Dome Light Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code Blue</td>
<td>1</td>
<td>Flashing Blue</td>
</tr>
<tr>
<td>Staff Emergency</td>
<td>2</td>
<td>Flashing Red</td>
</tr>
<tr>
<td>Bathroom Emergency Call</td>
<td>3</td>
<td>Flashing White</td>
</tr>
<tr>
<td>Normal</td>
<td>4</td>
<td>Steady White</td>
</tr>
<tr>
<td>Staff and Duty</td>
<td>5</td>
<td>-----------</td>
</tr>
</tbody>
</table>

D. Audible annunciation of incoming calls shall be accomplished by increasing of tone pulse frequency with increased priority level on system annunciator panels, master stations, duty stations and zone dome lights.

1.9 FUNCTIONAL REQUIREMENTS

A. Networked IP Based Audio/Visual Nurse Call System:

1. The networked IP (internet protocol) based audio/visual nurse call systems shall provide a complete two-way full duplex voice intercommunication, monitoring, and signaling facility for a given department combined with special features described herein such as entertainment and lighting controls, etc. Provide networking between multiple departmental systems (and connect to existing nurse call systems) for the purpose of centralized code blue and pocket paging monitoring.

2. The master stations shall provide visual and audible tone classification of calls placed on the system. All calls shall be identified individually by location and priority level. The master station shall provide said visual classification and location by a digital display. If a normal or staff call is placed from a peripheral station with voice capability, the master station will permit answering of calls by call classification and/or sequence of call, as desired by owner, through software programming. All other call classification types shall automatically take priority.

3. Announce normal, personal attention, priority, staff emergency calls by a classifying visual digital display and audible tone on the system master stations, duty stations, and zone dome lights, and by a classifying visual indication on the activating stations associated local dome light.

4. Announce staff and duty calls by a classifying visual digital display and audible tone on the system master stations.

5. Indicator room ready/cleaning needed, nurse presence, LPN presence and aide presence status by a classifying visual display on the system master stations, and by a clarifying visual indication on the activities stations associated dome lights.

6. All activating stations shall have a call placement indicator light to assure a call has been placed.

7. All normal, duty and staff calls shall have cancel capability at both the master station and the activating station. All other call classifications and status indicators shall be canceled only at the activating station.

8. Patient stations shall have the ability to be placed in either the normal, personal attention, or priority call modes of operation through master station programming.
9. Equipment hardware shall be of the modular plug-in type design for expanding functions and operations, for system reconfiguration, expansion and maintenance.

10. Patient stations can be set to a Privacy mode that allows one way audio into the room if the nurse master station initiates audio but allows two-way audio if patient initiates a call. The call assurance light on station flashes slowly and indication shown at nurse master.

B. Code Blue Visual Nurse Call System:
   1. The code blue visual nurse call system shall provide visual and audible tone classification of calls placed on the system.
   2. Announce code blue calls by a classifying visual display and audible tone on the system annunciator panels, master stations, and zone dome lights, and by a classifying visual indication on the activating stations associated local dome light.
   3. Report code blue calls by an audible tone and visual departmental signal at the telephone switchboard location via a code blue annunciator and/or zone dome light.
   4. All activating stations shall have a call placement indicator light to assure a call has been placed. All calls shall be canceled only at the activating station.
   5. Control cabinet hardware may be separate or an integral part of other departmental nurse call systems as described herein. All code blue wiring shall be supervised.

C. Nurse Call Systems Network Platform:
   1. The nurse call systems network platform shall provide for centralized access, monitoring, and reporting of new nurse call systems by a nurse call system network.
   2. Access from networked PC shall allow password authorized read-time and historical:
      a. Set service requirements, attach tag message (canned or free-text) and display/record message.
      b. Call/status and time durations to answer call.
      c. Staff directory, assignments and locations.
      d. Staff sign-on and sign-off functions.
      e. Bed management.
      f. Patient status and tracking.
      g. Nurse management software.
      h. Equipment location tracking.
   3. Furnish TCP/IP connection, from the new (and existing) nurse call systems to the Owner’s (existing) LAN/WAN, for any Owner’s networked PC passworded access to the nurse call systems platform network.

1.10 COORDINATION
A. Refer to Drawings for entertainment jacks/cabinets, lighting relays/cabinets, patient serving units, elapsed timer locations, etc.

B. Recommend to Owner and request approval of nameplate inscriptions on systems annunciators and master stations prior to fabrication.

C. Coordinate together with equipment suppliers and other Divisions, equipment operational voltages and controls for proper system operation. Provide any necessary auxiliary equipment for system interfaces. The auxiliary equipment shall provide for, but not be limited to:
   1. Existing nurse call systems interfaces.
   2. Patient entertainment controls including isolation module for filtering digital television noise.
   3. Patient service column installations.
   4. Patient lighting controls.
   5. Code blue system interfaces.
6. Nurse call systems and network platform (gateway and) interfaces.
7. Owner's facilities and networks group(s) requirements.
8. Pocket page interfaces.
10. Staff (and equipment) infrared locater interfaces.

1.11 WARRANTY AND SOFTWARE AGREEMENT

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace system components and batteries that fail in materials or workmanship within specified warranty period. Special warranty applies to materials only, for period specified.
   1. Warranty Period: Include the following warranty periods, from date of Substantial Completion:
      a. Full Warranty: Five years, except patient control units and cord sets which shall be minimum 2 years.

B. Special Software Agreement: Manufacturer agrees to provide site specific software, software updates, and licensing for the expected life of the system or 20 years minimum.
   1. Provide customized user programmable functions and features prior to system final acceptance.

1.12 EXTRA MATERIALS

A. Provide systems spares, spare parts, and accessories for general operation and maintenance. Include items listed below and items recommended by manufacturer.
   1. 3 Patient control units
   2. 5 Cord savers.
   3. 5 Keys for lockable devices.
   4. 2 Dome lights.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS (MAKE - SYSTEM SERIES)

A. Network based Audio/Visual Nurse Call Systems:
   1. Rauland-Borg - Responder 5.

2.2 GENERAL NURSE CALL SYSTEM COMPONENTS

A. Pushbutton Type Patient Station:
   1. Flush wall mounted.
   2. Call placed indicator.
   3. Call/cancel switch.

B. Toilet/Dressing Room Station:
   1. Flush wall mounted.
   2. Call placed indicator.
   3. Positive latching call switch from 12 inch vinyl pullcord.
5. Pull for help faceplate identification.
6. Rauland #354000

C. Bath/Shower Station:
   1. Flush wall mounted.
   2. Water-resistant faceplate with backbox gasket.
   3. Call placed indicator.
   4. Positive latching call switch from vinyl 12 inch (bath), 5 feet - 0 inch (shower) pullcord.
   5. Cancel switch.
   7. Rauland #354001

D. Dome Light:
   1. Ceiling mounted unless otherwise noted.
   2. White translucent acrylic snap-on plastic lens assembly.
   3. Dome lights shall contain four sections, each lighted by a long life, RGB LED capable of producing 7 colors. Each section shall have a diffusion lens which allows for 180 degreee horizontal visibility of call lights.
   4. Rauland #352000

E. Two Jack Station:
   1. Two (2) isolated inputs for auxiliary alarms (vent, chair, and IV)
   2. One gang adapter plate
   3. Cancel button
   4. Install antimicrobial bio-seal cover for disinfecting station.
   5. Rauland #354018

F. Cordsets:
   1. Ten-foot-long cord with jack to match activating stations, call actuating device, and jaw type bed clamp.
   2. Call activating device shall be the following type:
      a. Patient Control Unit (Pillow Speaker) – Prep-Recovery.
   3. Jack and activating device shall be molded to cord preventing wire termination damage. Molding and cord shall be durable neoprene or poly-vinylchloride designed to withstand sterilization procedures.

G. Equipment Cabinet:
   1. Surface and/or flush mounted code gauge cabinet with hinged key lock door.
   2. Cabinet shall be sized, as required, for installation of equipment panels, power supplies, and all other equipment required for proper system operation.
   3. Shall have system identifying nameplate centered on cover (i.e. NEC #2A).
   4. Built-in nickel-cadmium battery backup providing five minutes’ full system operation during a power failure.

2.3 NETWORKED BASED NURSE CALL SYSTEM COMPONENTS

A. Enhanced Single Patient Station:
   1. Functions as single bed station with two (2) additional pushbuttons.
   2. Multiple call-in priorities available.
3. Tilt/Release DIN receptacle for pillow speakers with patient entertainment controls and handset intercom with entertainment muting during nurse call.

4. Tilt/Release DIN receptacle allows for ease of disconnecting Pillow Speaker from the patient station.

5. Interfaces with specialty beds via separate receptacle and control module.

6. Interfaces with a remote Pillow Speaker via separate station.

7. Rauland #353001

B. Staff Station/Staff Terminal:

1. Flush wall mounted.

2. Color touch screen LCD display.

3. Programmable to assign, place, answer and cancel calls.

4. Work flow programming includes:
   a. Anesthesiologist notifications.
   b. Food service notifications.
   c. House Cleaning notifications.
   d. Laboratory notifications.
   e. Maintenance notifications.
   f. Nursing staff notifications.
   g. Security notification.
   h. Other notifications to be defined by Owner.

5. Programmable intercom feature to call master stations and other LCD Staff/Duty Stations.


7. Cone type speaker/microphone with full duplex audio.

8. Rauland #351300

C. Duty Station:

1. Flush wall mounted.

2. Call placed indicator.


4. Button type cancel switch.

5. Monitor indicator.

6. Cone type speaker/microphone with full duplex audio.

7. Call indicators and tones to announce normal, personal attention, bathroom, and priority calls. Call tones generated at duty station must be identical and repeat on system with tones provided at nurse console.

8. Rauland #351300

D. Master Station (Nurse Console):

1. Desk top unit shall have umbilical cord with plug, matching receptacle, and cover plate.

2. Control panel with seamless scratch and water resistant touch sensitive switches, LCD displays, and indicators, speaker/microphone, and handset for confidential conversations.

3. Rauland #351200

E. Master Station Functions:

1. Display:
   a. Sequential simultaneous alpha-numeric display by highest priority and age of a minimum of three calling stations indicating room number, bed number or letter and call classification.
   b. Sequential display of patient stations in priority mode.
c. Sequential display of patient stations in personnel attention mode.
d. Sequential display of patient stations in privacy mode.
e. Sequential display of patient stations in monitor mode.
f. Sequential display by staff level of patients requiring service.
g. Display of up to three incoming calls each with an individual elapsed timer which increments since call was placed, patient information, and associated staff members' names.
h. Feature keys capable of any present or future user-definable features.
i. Ability to program remotely from a network interface all console functions, touchprints, and priorities.

2. Controls, indicators, and automatic features:
   a. Key-pad for initiation and receipt of calls.
b. Push to Talk switch with indicator for speaker/microphone communication.
c. Hold and recall switches to place and retrieve current call on hold.
d. Normal, Personal Attention and Priority switches to program or display individual station call classification and medical status.
e. Privacy indicator to show station privacy activated.
f. Audio page switch(es) to make announcements to one or more stations, and to external overhead paging system.
g. Monitor switch with indicator to listen at one to 8 stations over the speaker.
h. Future Pocket page (wireless phone text message) interface capabilities including:
   1) Tag messages detailing patient requirements.
   2) Group page.
   3) Automatic mode of routine patient calls to assigned staff.
   4) Console operator call screening prior to pocket page (wireless phone) dispatch).
i. Future Wireless phone audio interface:
   1) Answer patient calls.
   2) Set service requirements.

j. Volume control.
k. Tone selector.
l. Tone mute of calls in progress.
m. Speaker tone shall audibly indicate highest priority incoming call classification.
n. Selection of call answering by priority and/or age of call.
o. Reminder tone of service requirements not answered within an allotted time frame.
p. Initiate/receive calls from other master stations associated with same equipment cabinet as well as other equipment cabinets).
q. Parallel operation with other master stations).
r. Ability to swing an individual room or any group of rooms by touching one labeled touch point.
s. Ability to block all loudspeaker paging to facilitate a low noise patient environment. Password protection can be enabled to allow only authorized access to audio paging.

3. Programmable Functions:
   a. Patient station medical status (normal, priority, or personnel attention).
b. Day-night room or zone transfer to another master station within system.
c. Room or group monitoring.
d. Group and/or zone page.
Froedtert Health
Milwaukee, Wisconsin
Master Specifications Version 7

NURSE CALL SYSTEMS

F. Data Interface Module:
   1. Furnish as necessary, data interface modules to provide the following features:
      a. System programming via RS-232 port of all network control stations, sub-stations, console functions, assignments and entire network operation from a single interface point either on site or off site (via modem).
      b. Upload all network component firmware to flash memory either on site or off site (via modem).
      c. Network administration of pocket page setup.
      d. PC interface for diagnostics of all network components on or off site.
      e. Pocket page interface (Motorola PET and TAP protocol).
      f. Management Software PC interface.
   2. Systems requiring local programming of individual network components/sub-systems at multiple physical locations or which do not allow for remote upload of component firmware, will not be accepted.

G. Universal Interface Modules:
   1. Provide as required universal station modules for visual call type stations. (Provide one per station). This unit shall also be capable of providing auxiliary alarm device contacts inputs for nurse console notification of a local alarm(s) and corridor light/zone light control where necessary.

H. Patient Control Unit (Pillow Speaker):
   1. Ten-foot-long cord with jack to match actuating station and required terminations for the following handset devices:
      a. Cone type speaker/microphone.
      b. Volume control.
      c. Call button.
      d. Lighting on/off button.
      e. Television on/off and channel select button.
   2. Jack and handset shall be molded to cord preventing wire termination damage. Molding and cord shall be durable neoprene or poly-vinylchloride designed to withstand sterilization procedures.
   3. Handset shall be fabricated of high impact, molded plastic designed to withstand sterilization procedures.
   4. Jaw type bed clamp shall be provided on cord.
   5. When plugged in, shall deactivate patient station speaker/microphone.
   6. Cord Saver or flexible jack minimizing repair of pulled out cordset.

I. Equipment Cabinet/Hub Controller:
   1. Surface and/or flush mounted code gauge cabinet with hinged key lock door as shown on Drawings.
   2. Cabinet/controller shall be sized, as required, for installation of equipment panels, power supplies, nurse consoles, all downstream peripheral devices and all other equipment required for proper system operation.
   3. Features:
a. Modular plug-in design.
b. Embedded System Architecture: In the event of a power failure, the system shall retain programmed information in memory (non-volatile memory), such as room numbers, bed identification, priority status, etc. Upon restoration of power, system shall return to normal and any pending calls will reannunciate at masters and duty stations.
c. Self-diagnostics shall report to all system master stations of system through console display.
d. Power supplies for lighting relays.
e. Voice circuit switching shall be accomplished with solid state circuitry.
f. Electromechanical devices shall not be included within system switching hardware.
g. Shall have system identifying nameplate centered on cover (i.e. NEC #2C).
h. Built-in nickel cadmium battery or UPS backup providing five minutes of full system operation during a power failure.
i. Provisions for future wireless telephone and pocket page interface modules.

4. It shall be possible for network hub to act as a stand-alone controller should loss of network communication occur.

J. System Diagnostics:

1. All components in the system shall be continuously supervised for both power and data to ensure proper operation and in the case of system faults to aid in troubleshooting.
2. It shall be possible, from any designated network data interface location, on or off site, to diagnose all network active components, hub controllers, control stations, and sub-station operation. Network administrator shall be able to:
   a. Review system faults reported (i.e. control station, sub-station failure).
   b. Place control station or network interface devices into interrogation mode for the purpose of running a diagnostic check of electronic components.
3. Hub controller shall report faults or failure of assigned control, or network interface devices in plain English to its designated nurse consoles.
5. Provide separate chassis short monitor to monitor integrity of network wiring for short(s) to earth ground. An audible alert tone shall sound if short is detected. Provide test button to test operation.
6. Provide separate power fault monitor to notify staff of loss of power. Should a loss of power, or power brownout occur, an audible alarm will sound. Provide test button to test operation.
7. (Provide as required chassis short monitor, power fault monitor, and code blue stations to qualify system for Supervised Code Blue operation. As such, the system shall supervise code blue stations for power, data, and open, shorted, or missing code blue bulbs.)

2.4 CODE BLUE VISUAL NURSE CALL SYSTEM COMPONENTS

A. Staff Assist/Code Blue Station:

1. Flush wall mounted.
2. Call placed indicator.
4. Staff Assist Faceplate identification.
6. Shall automatically start elapsed timers in associated patient vicinity if so equipped.
7. Plastic clear cover to prevent accidental button depression.
8. Rauland #354012

B. Equipment Cabinet:
1. May be separate or an integral part of other nurse call systems cabinets, sized with components necessary for proper system operation.
2. If separate, shall have identifying system nameplate centered on cover (i.e. CODE BLUE) and hinged key lock door.

2.5 NURSE CALL SYSTEMS NETWORK PLATFORM COMPONENTS

A. Network Hardware:
1. Nurse call LAN must be separate server(s) to meet system capacities and functional requirements*
   a. One serial, one LAN adapter card and one USB port in addition to those required by the monitoring communications system network interface module at 500K baud communications speed.
   b. UL 1449 listed Transient Suppressor/Power Conditioner with 150% VA rating of initially connected equipment.
2. Owner’s networked PC, password access to the nurse call LAN, without additional Owner software.
   a. 19” Color monitor.
   b. Mouse and operating software.
   c. One NIC and one USB port in addition to those required by the monitoring communications system network interface module.
   d. 101 Key Enhanced full-sized keyboard.
3. Color graphics capable ink jet printer.
4. Include two sleeves of 500 count 8-1/2 x 11 paper and one extra set of ink cartridges.

B. Network Gateways or Bridges:
1. Owner’s Network:
   a. TCP/IP connection, from the nurse call LAN to the Owner’s (existing) LAN/WAN, for any Owner’s networked PC password access to the nurse call network without additional Owner software.
   b. Integrity of the Owner’s LAN/WAN and the nurse call network shall be assured such that a failure in one cannot affect the other for life safety grade reliability of nurse call functions.
2. Integrated Systems Network:
   a. Middleware (such as ConnexAll or Emergin event management software) and associated hardware shall be minimized to reduce potential failures.
   b. SIP (Systems Integration Protocol) shall be maximized to reduce or negate all middleware software and hardware and maximize data throughout.

C. Network Software:
1. Information Display:
   a. Full English display.
   b. Selectable call-in status priority levels.
c. Display of unlimited number of incoming calls each with an individual elapsed timer which increments since call was placed.
d. Change display color of each type of call priority.
e. Allow networked PCs to access an individual customizable display.
f. Set up multiple views of call displays, password protected.
g. HL7 interface feature with whiteboard information display.

2. System Diagnostics:
   a. Diagnose all network active components, hub controllers, control stations, and substation operation. Network administrator shall:
      1) Review system faults reported (i.e. control station, hub failure).
      2) Place control station or network interface devices into interrogation mode for the purpose of running a diagnostic check of electronic components.

2.6 SYSTEMS WIRING AND CABLE
   A. Suitable for areas installed and raceways utilized per manufacturer's recommendation and code requirements.
   B. All code blue wiring shall be supervised.

PART 3 - EXECUTION

3.1 GENERAL
   A. Review Drawings for systems designations, systems boundaries, device locations, handset type and locations, zone designations, trunk risers, and special features.
   B. Provide interconnecting wire and cable between the various system devices for proper system operation as recommended by the manufacturer's representative. Include entertainment and lighting control wiring.
   C. Install wire and cable in conduit raceways for the following applications:
      1. When located behind non-accessible building construction. Z-spline ceiling types shall be considered not accessible.
         a. Provide conduit stubbed into accessible corridor ceiling space from flush wall mounted, non-accessible ceiling mounted, and patient serving mounted device outlet boxes.
      2. From system equipment cabinet to accessible ceiling.
         a. Size conduit to provide 33% spare capacity for future wiring.
      3. From system equipment cabinet to associated system master stations, annunciators, and to equipment cabinets of other systems (if required).
      4. From patient station to associated television jack and lighting relay.
      5. From device outlet boxes and equipment cabinet to accessible ceiling space.
      6. In conduit sleeves though fire and smoke partitions.
   D. Wire and cable not in conduit shall utilize saddle strap hangers’ maximum 3 foot on center.
   E. Size raceways and associated boxes as required by the National Electrical Code limiting fill to 30 percent unless otherwise indicated or further reduced by manufacturer's representatives' recommendations. Terminate all conduits with bushings.
F. Identify components per Division 26 Section “Electrical Identification”.

3.2 INSTALLATION

A. Install outlet boxes of size and type recommended by manufacturer’s representative to suit device and location shown on Drawings. Provide collars over sides of all surface mounted boxes where station coverplate is larger than box to match coverplate. Install equipment cabinets at five feet above floor, unless otherwise noted, supported independent of stud partitions.

B. Install raceway systems and ground per applicable codes.

C. Separate speaker-microphone, line-level, speaker-level, and power-wiring runs. Run in separate raceways or, if exposed or in same enclosure, provide 12-inch (300-mm) minimum separation between conductors to speaker microphones and adjacent parallel power and telephone wiring. Provide separation as recommended by equipment manufacturer for other conductors.

D. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks if required.

E. Identification of Conductors and Cables: Retain color-coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with system wiring diagrams. Label stations, controls, and indications using approved consistent nomenclature.

F. Install wire and cable making no splices. Provide minimum twelve inch pigtails at outlet boxes for equipment. Tag at each end.

G. Make all connections to screw type terminals, connectors or terminal boards. Use matching plugs or receptacles where required. Spliced cables or soldered connections are prohibited. Identify and label all wire terminals and blocks.

H. Label equipment cabinet components by functional description.

I. Bath/Shower Stations: Assure nylon pull cord length is within 2 inches of the finished floor.

J. All programming will be provided by Froedtert IT. Contact the IT department at FCHITClinicalApplications@froedtert.com, when ready.

3.3 EXISTING SYSTEMS TESTS

A. Examine existing systems for proper operation, compatibility with new equipment, and deficiencies. If discrepancies or impairments to successful connection and operation of interconnected equipment are found, report them and do not proceed with installation until directed. Schedule existing systems’ examination so there is reasonable time to resolve problems without delaying construction.

3.4 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other signal impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding except at connection to main building ground bus.

C. Grounding Provisions: Comply with requirements in Division 26 Section "Grounding."
3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform tests and inspections.
   1. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Test and Inspections:
   1. Schedule tests a minimum of seven days in advance of performance of tests.
   2. Report: Submit a written record of test results.
   3. Operational Test: Perform an operational system test, and demonstrate proper operations, adjustment, and sensitivity of each station. Perform tests that include originating station-to-station and all-call messages and pages at each nurse call station. Verify proper routing, volume levels, and freedom from noise and distortion. Test each available message path from each station on the system. Meet the following criteria:
      a. Speaker Output: 90 dB plus or minus 3 dB, 300 to 3000 Hz, reference level threshold of audibility 0 dB at 0.02 millipascals of sound pressure.
      b. Gain from patient's bedside station to nurse station, with distortion less than 65 dB (plus or minus 3 dB, 300 to 3000 Hz).
      c. Signal-to-Noise Ratio: Hum and noise level at least 45 dB below full output.
   4. Test Procedure:
      b. Signal-to-Noise Ratio: Measure the ratio of signal to noise of the complete system at normal gain settings, using the following procedure: Disconnect a speaker microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure the ratio of signal to noise and repeat the test for four speaker microphones.
      c. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 300, 400, 1000, and 3000 Hz into each nurse call equipment amplifier, and measure the distortion in the amplifier output.

D. Retesting: Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense. Verify by the system test that the total system meets these Specifications and complies with applicable standards. Report results in writing.

E. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sound levels and controls to suit actual occupied conditions. Provide up to three four-hour visits to Project during other-than-normal operating hours for this purpose.
3.7 DEMONSTRATION

A. Froedtert IT will set up and train maintenance personnel and caregiver staff to program, adjust, operate, and maintain nurse call equipment. Refer to Division 01 Section “Demonstration and Training” and requirements below.

END OF SECTION 275223
28 00 00 – SECURITY MANAGEMENT SYSTEM (SMS)

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. The Owner’s general provisions of the Contract, including General and Supplementary Conditions, and Bidding Instructions, apply to this Section.

B. Project Dates:
   1. x – Bid package released
   2. x – Mandatory bid meeting, two representatives only from the Bidder’s company
   3. x – Requests for information or clarification due to the Owner’s Representative
   4. x – RFI Response(s) released
   5. x – Bid closing at 10 a.m. bids submitted after this time will not be accepted
   6. x – Bid Award
   7. x – Preconstruction meeting
   8. Initiate construction – x
   9. Complete Construction – x

C. Project Location
   1. Example - Main Street, Anytown USA, 00011

D. Security Equipment Drawings, Details, System Riser Diagram, Door and Device and camera schedules apply to this Section.
   1. Project drawings - The security drawings provided with the solicitation to bidders are diagrammatic only and are not intended to show every detail of construction or arbitrary location of wiring. Each system shall be complete with minor parts not specifically noted in the drawings but are required for a properly functioning system conforming to state and local codes.
      a. TY010 [Title Page, General Notes, Legends]
      b. TY100 [Site Security Plan]
      c. TY101 [Building X Floor X Security Plan]
      d. TY102 [Building X Floor X+1 Security Plan]
      e. TY103 [Building IV Floor 2 Security Plan]
      f. TY200 Camera Schedule
      g. TY201 Door Schedule
      h. TY300 Termination Schedule
      i. TY400 Security Installation Details, Page 1
      j. TY401 Security Installation Details, Page 2
      k. TY402 Security Installation Details, Page 3
PROJECT SUMMARY

A. Removals, relocations, rearrangements

1. The Drawings may indicate renovated areas and identify those portions of buildings where renovation work shall be provided. Identified areas of buildings show electronic safety and security work systems that shall be provided.

2. Removals, relocations and rearrangements shall be performed in all identified areas, as shown on Drawings.

3. If the Contract Documents include D500 series Demolition Drawings, these Demolition Drawings shall be interpreted as incomplete, and in general represent existing building electrical conditions.

   a. The Demolition Drawings included in the Contract Documents are not to be considered complete or accurate and are included only to provide the general scope and extent of selective removals, relocations and rearrangements to be included. Visit the site prior to submitting the bid, to verify existing building conditions, in order to more accurately establish the removals, relocations and rearrangements required.

   b. The Demolition Drawings include description notes that provide an overall intent of removals, relocations, and rearrangements.

4. Examine the existing structures and installations for the work of other trades which will influence the cost of the work on this project. Include removals, relocations and rearrangements affecting the work of this Division as follows:

   a. Relating directly or incidental to the construction.
b. The work of other Divisions which may interfere with, disturb, or complicate, the performance of the construction.

c. Involving systems and/or equipment and their relocated service lines, which shall continue to be used or operated as part of the finished project.

B. This Section is intended to provide overview of the requirements for the provision of all NEW equipment, materials, labor troubleshooting, documentation, programming, and services necessary to install a new SMS at the project location, which will consist of:

1. Expansion of the existing SMS.

2. Providing card readers, door contacts, electrified locking hardware, badging client workstation, loading software onto existing computers, network connected panels and field devices, provisioning for web-based clients.

3. Providing connections to electromechanical hardware.

4. Providing electromechanical hardware.

5. Providing all panel hardware, enclosures and low voltage power supplies to support the requirements of this scope of work.

C. The entire project scope has been broken down as follows:

1. Base bid, including panels and electromechanical locking hardware.

2. Option 1 – Provide a Pre-Warranty Inspection, Test and type written report of point-by-point test results as described herein. *Note: this option may or not be purchased/exercised for one or multiple years after the first year. The decision to purchase ongoing preventative maintenance will be based largely on the performance of the winning bidder throughout the installation process and subsequent first year’s servicing of the system. Pricing submitted for this option shall be held and made available for purchase by the Owner through the first year’s warranty service period.*

D. The Contractor is required to provide all low voltage power, power supplies, wire and raceways for this project with the exception of CAT6 cabling for data drops. CAT6 patch cables shall be provided by the Contractor.

E. The Contractor is responsible to furnish and install all conduit and raceways in and around access control panels for this project as shown on the panel elevation detail drawings.

F. The Division 08 Contractor will provide prep for electromechanical locking hardware and recessed door contacts on new openings affected by this scope. However, existing door locations will need to be field prepped and/or modified to accept the hardware scheduled within these Contract Documents.

G. Access Control:

1. Provide a complete and fully functional SMS system as specified herein.

H. Video Management System:
1. Provide an IP based video management system components as specified herein.

2. Video shall be recorded for a minimum of sixty (60) days to support loss investigations.

3. Video shall be integrated with the SMS to enable video images to be displayed on a call up monitor when selected alarms are activated during business hours. Video shall be configured and displayed as desired by the Owner.

4. Where specified, cameras shall be integrated with alarms from the SMS and alarm call up video displayed at the security system monitoring station(s). Video alarm events shall be stored on the SMS server. The video system shall enable anyone given privileges from the site security manager or other Owner designee(s) the ability to view live and recorded video. Correlations specified between alarm points and video cameras can be found in the TY 200 Camera Schedule within the Contract drawings.

I. ADMINISTRATIVE REQUIREMENTS

1. Substitutions:
   a. The materials, products, and equipment described in the Bidding Documents establish a standard of required functions, dimensions, appearance, and quality to be met by any proposed substitution.
   b. No substitution will be considered prior to receipt of Bids unless written request for approval has been received by the owner’s Technical Maintenance Division Supervisor in collaboration with the Security Directors, and the Architect/Engineer at least ten (10) days prior to the date for receipt of Bids. Each such request shall include the name of the material or equipment for which it is to be substituted and a complete description of the proposed substitute including drawings, cuts, performance, test data and warranties, and any other information necessary for an evaluation. A statement setting forth any changes in other materials, equipment, or other work for incorporation of the substitute shall be included. The burden of proof of the merit of the proposed substituted is upon the proposer. The architect shall confer with the owner’s Directors of Security and Technical Maintenance Division Supervisor. The Architect’s decision of approval or disapproval of a proposed substitution shall be final.
   c. If the Architect approved any proposed substitution prior to receipt of Bids, such approval will be set forth in an Addendum. This Addendum shall then be issued to all Bidders.
   d. Requests for Substitution shall be made only by a Bidder. Requests for Substitution received by the Architect from others (e.g., sales representatives, vendors, suppliers) are not acceptable.
   e. Refer to Division 01 for instructions on substitutions.

2. Permit and Inspections:
   a. Permits: Obtain and pay for all permits, bonds, licenses, tap-in fees, etc., required by the City, State, or other Authority Having Jurisdiction over the work, as a part of the work of the affected sections.
b. Inspections: Arrange and pay for all inspections required by the above when they become due as part of the work of the sections affected. Conceal no work until approved by these governing authorities. Coordinate inspection period with the AHJ and Engineer through Construction Manager. Present the Engineer with a properly signed certificate of final inspection.

3. Coordination:
   a. Coordinate all programming components, device designations, and labels to match the final room numbers of the completed project. The room numbers on the Drawings may not be the final room numbers and may be finalized after system components are installed.
   b. Coordinate arrangement, mounting, and support of Division 28 equipment:
      1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
      2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
      3. To allow right of way for piping and conduit installed at required slope.
      4. Connecting raceways, cables, wireways, cable trays, and pathways will be clear of obstructions and of the working and access space of other equipment.
   c. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
   d. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section “Access Doors and Frames.”
      1. Submit coordination drawings indicating proposed access door locations for review per Division 28 Section “Common Work Results for Electronic Safety and Security.
      2. Ensure access doors are sized to permit complete access for any concealed and/or inaccessible junction boxes, control and monitoring devices, elevator shaft and other items of equipment requiring access, maintenance, and/or operation.
         a. Assure access to devices per codes and local Authorities Having Jurisdiction.
   e. Wiring and controls associated with equipment shall be furnished, installed, and wired in accordance with the manufacturer’s recommendations and applicable standards and codes. Provide installation instructions, locating dimensions and wiring diagrams for the other trades. Supervise the installation and start-up and test the equipment unless otherwise specified.
f. Equipment Furnished by Other Divisions: Equipment specified in other divisions and requiring communication and control connectivity shall be erected, aligned, leveled, and prepared for operation. Provide required controls and accessories along with installation instructions, diagrams, dimensions and supervision of installation and start-up. Provide the required terminations, accessories and programming furnished under the specifications for the other divisions. Install those controls and accessories not located in the provided equipment. Provide additional electrical controls, accessories, fittings and devices not specified under the equipment but required for a finished, operating job. Make final electrical connections. Participate in the start-up and test services.

J. Training as outlined in Section III Execution.

K. Submittals as detailed within.

L. Work out of scope:
   1. Wall mounting locations for network connected equipment and panels.
   2. Access to the System Server for the purpose of configuring the system.
   3. All client personal computers associated with the SMS with the exception of the badging computer.
   4. KVM and UPS for SMS Server
   5. Equipment rack for SMS Server, space will be designated within the MDF.
   6. An empty circuit breaker within the nearby electrical distribution center for the Contractor to connect and install dedicated circuit(s) for the security systems.
   7. Line voltage power for security equipment.  Note: The Security Contractor is responsible for ensuring that the Electrical Contractor is fully coordinated with the requirements set forth within SECTION 3 of this specification and the Contract Drawings, for the installation of line voltage power and line voltage power devices such as, but not limited to, boxes, receptacles, switches and surge suppression. Failure to fully coordinate these requirements may result in a re-work of line voltage power by the Electrical Contractor. Any costs associated with the remediation of the line voltage power or devices may be the responsibility of the Security Contractor, if it is deemed that they have been negligent with the coordination.
   10. Final programming for SMS doors and VMS cameras will be performed by FH Technical Division. Programming will be governed by the Owner’s Genetec Matrix.
   11. Training on the SMS.
   12. Conduit stubs and back boxes at door locations as well as line voltage to panel locations (By Division 260000).
   13. Fire Alarm drops for access control panel locations.

1.03 SYSTEM DESCRIPTION

A. Provide project management services for the installation to include:
   1. A single point of contact for all project related items.
   2. Participation in weekly project conference calls.
3. Participation in on-site construction meetings as needed.

4. On-site supervision as necessary or requested as installation issues arise or coordination with another trade is required or requested by the GC and/or other coordination trades requesting such a visit.

B. Mapping:

1. Approval of SMS Mapping feature install by Technical Maintenance Supervisor, IT Infrastructure and IT Business Applications.

2. Provide and program the SMS with an integrated graphical mapping feature to include the following:
   a. Provide one overall floor plan for each floor.
   b. Allow two zoomed in views per floor.
   c. Each level floor plan view shall have icons for each alarm point that is reporting into the SMS.
   d. Each floor plan level view shall have icons for each video camera that is installed.
   e. All device icons shall be positioned as closely as possible to the actual field location of the installed device.
   f. Icons shall be ‘live’ allowing the operator to see the status of a monitored point or door as well as perform functions such as, among others, valid unlock (without alarm), shunt and acknowledge.
   g. All floor plan views shall be “clean” meaning absent of any SMS drawing symbols, leaders or callouts so that the live icons can be placed with minimal clutter to the floor plan.
   h. Room numbers and names shall be visible on the floor plan views.
   i. Live SMS icons shall be placed to minimize overlap onto room names and numbers as much as possible.

3. Icons mapped onto the floor plans shall be inclusive of the following types:
   a. For all access-controlled doors:
      1. Forced open alarm.
      2. Held open alarm.
      3. Door status: open or closed.
   b. For all monitored doors: alarm condition.
   c. All Event alarms.
   d. All video cameras
   e. All reader tamper alarms.
   f. All secondary monitoring features such as:
      1. Power Failure.
      2. Power supply trouble and battery fault.
      3. Fire Alarm release.
4. Panel Tamper Alarms.

5. Note: The secondary monitoring icons may be invisible until an alarm / trouble condition is present.

4. Provide maps for incorporation of this requirement in one of two formats:
   a. Black line image on a white background or,
   b. White line image on a black background.
   c. Image format shall be coordinated with the Owner prior to programming the mapping feature.
   d. Image format shall be correct for the requirements of the SMS platform that is provided.

C. Provide SMS client station software as follows:
   a. Security Contractor to provide licensing in partnership with Froedtert IT Business Applications.

D. Access Control Function within the Security Management System (SMS)
   1. Card Readers:
      a. All card reads shall be connected via ODSP Version 2 to the Mercury based hardware. The Secure Channel® communication protocol will be implemented as part of this OSDP deployment.
      b. Provide necessary reader licensing.
      c. Provide programming for double-tap functionality on select access-controlled openings as noted within the Contract Drawings.
      d. Provide scheduling unlocks as noted within the Contract Drawings.
   2. Coordinate with the Owner’s IT department for initial connection to and configuration of the client stations to allow further programming of this site by the bidder.
   3. Door Position Switches
      a. All pedestrian doors within the scope of the project shall be treated with a recessed or surface mounted (as indicated in the device schedules and floor plans) door position switch, which reports openings and closings of each leaf to the SMS.
      b. New or replaced door contacts shall be either SPST or SPDT 1” recessed contacts, no exceptions unless noted as surface on the Contract Drawings.
      c. When a portal features multiple leaves, each leaf shall be monitored with its own separate contact set.
      d. When a portal features multiple leaves, the unauthorized opening of any leaf, individually and separately, shall cause an alarm. It should not be necessary to open more than one leaf at the same time to generate an alarm.
      e. Each door contact (except those on double leaved portals) shall be configured as a separate alarm point. The contacts shall activate when a disturbance in the magnetic field occurs.
      f. The door contact shall be rated for a minimum lifetime of one million operations.
g. Door position switches for emergency exit and overhead portals shall be connected to the SMS as input points.

h. Door position switches and Request to Exit (REX) utilized for permitted egress applications shall be connected to the SMS as individual input points and programmed so that the REX, when tripped, will shunt the door position switch. A direct hardwired shunt from the REX to the door position switch shall not be permitted.

i. Overhead door contacts shall be mounted as described in the installation typical details drawing.

2. Locking Hardware:

   a. The bidder shall assume that all electromechanical locking hardware prep will be completed by the time of work commencement for any given opening to receive electromechanical locking hardware or door contacts. Div. 08 pre work will consist of the following:

      1. Electromechanical exit device trim leversets.

      2. Electric hinges, both door and jamb sides.

      3. Pathway through the door between the electrified device and the electric hinge.

   b. Contractor shall perform their own coordination of electromechanical hardware prior to bid submittal.

   c. Hardware sets are shown in the Contract Drawing Schedule documents for reference to the current hardware set including a particular opening based on the Div. 08 hardware sets and architectural door schedules. These are for reference only and will be changed to electrified versions of the same. The Security Contractor shall assume that any hardware that needs to be installed under this scope will NOT be installed under the Div. 08 hardware scope in their non-electrified versions.

   d. Where exit device Event hardware with electrified exterior trim is required, the Security Contractor shall provide the entire exit device with the electrified trim. This is to ensure any installation and / or warranty issue responsibilities are correctly assigned.

   e. Electromechanical locking hardware designated with a Request-to-Exist switch where two request to exit devices are used shall have its contact output combined with that of the PIR REX so that either device will provide the panel with a REX signal.

3. Delayed Egress Devices:

   a. Any delayed egress device shall have its delayed egress cycle initiation monitored as a separate input to the SMS, from the door contact associated with the door on which the delayed egress device is mounted.
b. Monitoring of the delayed egress cycle initiation shall be individual by door location. If there are two leaves in a door opening and each has a delayed egress device, the two signals may be treated as one point to be monitored on the SMS.

c. An independent output from the SMS shall be wired to the inhibit/reset of the delayed egress device to perform a remote reset or extended shunt of the delayed egress device. A control output icon shall be placed on the mapping feature so that it is readily available to the operator.

d. Local resetting with a valid badge read.

e. An additional independent output from the SMS shall be wired to the IDS input for notification to the central station for openings not connecting to a Security Operations Center (SOC). The Central Station shall monitor this input as a 24/7 zone.

4. Event Devices:

   a. Event devices shall be connected to both the SMS and designated camera as specified in the camera schedule via a DPDT Event device.

   b. Event devices shall trigger visual annunciators as shown on the Contract Drawings. The visual annunciators shall illuminate any time the Event device(s) are activated. The visual annunciators shall be controlled by the SMS and fused individually by the auxiliary output power sources within the SMS power supply enclosure.

   c. Event devices shall be active 24x7.

5. Monitored Openings:

   a. There are several types of monitored openings (non-card access control) within the facility; these include:

      1. Emergency Exit Doors: doors, with no ingress or permitted egress (egress without alarm) allowed.

         a. Alarm sensor from these openings will report into the SMS as an input point and generate an alarm each time it is opened.

      2. Emergency Exit Doors: doors specified with local sounders to deter usage, with no ingress or permitted egress (egress without alarm) allowed.

         a. Alarm sensor from these openings will report into the SMS as an input point and generate an alarm each time it is opened.

      3. Overhead or roll up type doors and windows: these openings shall be monitored and are required to be programmed for shunting during business hours. After business hours, these door shall report to the security workstation client monitoring application.

1 Commonly referred to as duress or panic devices in the healthcare industry.
4. Permitted Egress: allowing egress of a space or the building without creating an alarm condition. Ingress would create an alarm condition that will annunciated on the security workstation client monitoring application.

6. Anti-Tailgate Detection:
   a. Anti-Tailgate Detection (TD) shall be applied to openings as shown on the Contract Drawings.
   b. The TD devices shall be specifically designed for the purpose of detecting a tailgating situation.
   c. The TD devices shall be wall mounted and consist of an optical powered transmitter (OTX) and optical powered receiver (ORX).
   d. TD devices shall contain an integrated local alarm and local integrated keyswitch override.
   e. TD devices shall be monitored by the SMS for tailgate alarm conditions.
   f. The TD alarm conditions shall be monitored as a separate programmed input specifically identified for the tailgate detection location and not shared with any other system input.
   g. The TD alarm shall be connected to a separate independent SMS output to allow for remote shunting of the device without utilizing the keyswitch. The output shall be connected to an inhibit circuit within the TD device. This control output circuit shall not disconnect power from either the OTX or ORX devices.

7. Passback & Passback Alarms:
   a. Openings, including turnstiles, where IN/OUT reader configurations are deployed shall be programmed for soft anti-passback and have a local sounder.
   b. For the purpose of establishing passback status, the perimeter locations where IN/OUT reader configurations are deployed will treat each IN reader as the “in” zone and each OUT reader as the “out” zone.
   c. Passback violations will occur until the credential is reset by Security personnel. Example: employee A enters through an IN reader by piggybacking in behind another employee. The next day, employee A encounters a passback violation at the entry point and the sounder goes off. Assuming that employee A does not have the credential stat reset, they leave that afternoon and encounters another local passback alarm that is also annunciated at the client stations’ alarm monitor workstation. This process will continue until the employee has the card state reset by Security personnel.
   d. Whenever a passback violation occurs, the alarm sounder shall sound for period of 10 seconds.
   e. In addition to the alarm sounder the passback violation shall be annunciated on the client stations’ alarm monitor workstation.
f. Upon initiation of the passback programming, all cards shall be set to an “unknown” state. Their first valid read after passback initiation at either an IN or OUT passback programmed perimeter location will determine the state of the credential.

8. Threat Levels:
   a. Threat levels shall be setup in a tiered system of Normal, Elevated and High.
   b. Threat levels shall be setup with three virtual button/icon placed on the monitoring screens of the client workstations.
   c. The following outlines conditions for each level:
   d. Normal – Shall be represented by a Green icon:
      1. Shall allow for any auto-unlock schedules to function as intended.
      2. Utilizing this icon shall cancel any Elevated or High postures and place any doors utilizing an auto-unlock schedule back into their scheduled state.
      3. Shall only require two-factor authentication: card and biometric, for entry into the BSL 3 and BSL 2+ labs.
   e. Elevated – Shall be represented by a Yellow icon:
      1. Utilizing this icon shall require three factor authentication: card, biometric and PIN, for entry into the BSL 3 and BSL 2+ labs.
   f. High – Shall be represented by a Red icon:
      1. Utilizing this icon shall activate any of the Elevated threat level conditions and:
      2. Remove any auto-unlock schedules for any site wide door location.

E. Video Management System (VMS)
   1. Video Cameras
      a. The Contractor shall provide video cameras to provide forensic video and assessment of alarm incidents. Unless otherwise noted, video cameras shall be IP and connected to the existing VMS head end.
      b. Interior cameras shall feature wide dynamic range.
   2. Camera Field of View
      a. All cameras are shown on the drawings in locations to provide the intended field of view. These locations are not to be adjusted without prior approval.
      b. In most cases the resolution of the camera and the properly adjusted lens will provide a minimum of 40 pixels per foot horizontal unless otherwise noted.
c. The Contractor shall plan for two full camera adjustments for each fixed camera installed. The first adjustment is to obtain the approximate field of view (FOV) and focus. The second adjustment is to fine-tune the FOV in coordination with the Owner and/or the Designer. Note: If the contractor feels they do not need this many adjustments, they may reduce them as they see fit, however, these minimum requirements will be enforced if necessary.

d. In addition to the two fixed camera adjustments listed above, the Contractor should plan on additional fine tuning adjustments in the amount of 25% of the total fixed camera count so that if a third adjustment at certain cameras is required, the Contractor will make these fine tuning adjustments at no additional cost to the project. When making this calculation, any fraction shall be rounded up to the next whole number. Example: A 20-fixed camera system would have 40 initial adjustments plus another 5 adjustments.

3. The Contractor shall install IP cameras at designated locations within and around each facility as shown on the Contract Drawings.

4. Camera types are identified in the Contract Documents by types for example, C1, C2, C3 etc. Each camera type defines the mounting condition and/or specific camera type.
   a. Camera Type C1 – Fixed interior or exterior vandal resistant wall pendant mini dome
   b. Camera Type C2 – Fixed interior vandal resistant ceiling mounted mini dome
   c. Camera Type C3 – PTZ exterior dome

5. Analytics:
   a. Analytics shall be setup for each camera type as noted within the Contract Drawings.
   b. Where edge based, analytic detection shall be fully ingested by the VMS.
   c. Examples of analytics to be programmed may include but not be limited to one or more of the following:
      1. Object detection (Person/Face/Vehicle/License Plate)
      2. Virtual Line/Area
      3. Enter/Exit
      4. Loitering
      5. Direction
      6. Intrusion
      7. Object color
      8. Motion detection

F. Intrusion Detection System

1. The IDS shall be provided with 1 partition upon installation but capable of providing 8 partitions total and shall be used for backup annunciation of Event alarms to the Central Station.

2. The IDS shall remain armed on a 24x7 basis.
3. Alarm conditions shall be reported to the IDS panel by means of SMS outputs that follow alarm conditions generated by each portal. Alarms shall be inclusive of Forced Open, Held Open, Delayed Egress (if used) and General Fault conditions from the SMS system. Each alarm condition described herein shall have its own alarm zone within the IDS panel. Only the General Fault Condition may share trouble and alarm conditions as described below.

4. SMS outputs shall be controlled via timing schedule so that all alarm outputs are shunting during business hours of the facility. The General Fault Condition output shall not be shunted.

5. Event buttons shall be connected to both the IDS & SMS via DPDT devices with separate circuit wiring to each system. No alarm output from the SMS to the IDS is required for Event buttons.

6. Provide sufficient input capacity for the IDS panel to accommodate the alarm inputs as described above.

7. Provide sufficient output capacity for the SMS panels to accommodate the alarm outputs as described above.

8. The IDS shall utilize Ethernet as the primary transmission method to the Central Station.

G. Systems Integration:

1. IDS – The IDS shall be integrated with the SMS in the following manner:
   a. Where specified, Event buttons shall be connected to both the SMS and IDS via a DPDT contact configuration. The Event shall be hardwired directly to the SMS and the IDS.

2. VMS – The VMS shall be integrated with the SMS in the following manner:
   a. All devices mounted on or part of, card access portals, monitored portals/windows and Event buttons in or near the field of view of any camera shall be integrated with the corresponding VMS camera or cameras for call up on a designated pane of a multi-view monitor.
   b. Alarm conditions shall be flagged within the SMS for review/call up at a later date.
   c. Alarm conditions shall be flagged within the VMS NVR for review/call up at a later date.
   d. Alarmed video shall call up in a separate window within the VMS Software Client and/or VMS Software Client, whichever is currently running.
   e. The recorded alarm video shall include, in addition to the duration of the alarm event, a recorded pre-alarm of 5 seconds prior to the start of the alarm event. **Note: Devices not in the direct field of view of the identified camera may require additional pre-alarm time to properly capture the intended alarm event.**
   f. The recorded alarm video shall include, in addition to the duration of the alarm event, a recorded post-alarm image for 5 seconds after the alarm event ends.
   g. Integration may be either hardwired or soft connection via TCP/IP protocols.
   h. Refer to TY 200 Camera Schedule for alarm point to camera associations.

H. System Fault Conditions:
1. Fault conditions for the SMS shall be monitored by the SMS by way of IDS inputs dedicated to the failure conditions **by panel location**. It is understood that several of the fault conditions listed below are monitored and generated from within the SMS. For these conditions, the contractor shall ensure that these conditions are properly annunciated on the end users SMS workstation monitoring screens along with the wired inputs.

2. All panels to be monitored with LifeSafety Power NetLink® power monitoring.

3. Where hardwired inputs to the SMS are required, they have already been identified and assigned within TY 300 Termination Schedules.

4. Where multiple fault conditions of the same type can be generated at one panel location, those conditions may be connected to a single input. For example: This will be the case where multiple power supplies are providing 12vdc power and another power supply at the same location is providing 24vdc power.

5. A single fault output from the SMS to the IDS shall be wired and programmed to send a signal to the IDS panel whenever a condition other than alarm, door forced or door held-open is generated by the SMS. These shall include and be limited to the following conditions:
   a. Short
   b. Open
   c. Supervision circuit value other than that of the alarm and normal circuit values
   d. 120vac Power Failure for each power supply connected
   e. Battery Loss, Life, Failure or Fault for each connected battery bank
   f. Any SMS enclosure tamper
   g. Any card or biometric reader tamper
   h. Mercury Hardware SIO communications failure
   i. Mercury Hardware loss of Ethernet connectivity
   j. Fire Alarm for secondary monitoring where present at a panel location

6. The IDS inputs shall be programmed according to the condition for which it is monitoring.

I. Coordination with other trades

1. Refer to 1.3-C of section 280500 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

2. Coordination shall take place to ensure that the requirements of this specification regarding the dependencies of those other trades is upheld.

3. Failure on the part of the Security Contractor to adequately coordinate with other trades may result in a rework of the coordination effort to comply with these specifications. Any associated cost for the rework may be the responsibility of the Security Contractor.

J. Post Installation Reports:
1. Between 60 and 75 calendar days after the established Warranty Start Date, the Contractor shall run Post Installation Reports (or assist the Owner in running reports) and submit them to the Owner and the Owner’s design representative for review. The report shall be run for all devices of the same type or classification for a given system installed under this Scope for the most recent thirty-day period. The purpose of the reports is to establish the system’s health and user compliance in using the systems. The following reports shall be run individually as listed below and submitted:

2. Access Control Function within the SMS:
   a. Door Held Open Report
   b. Door Forced Open Report
   c. All other Monitored points Report
   d. Tamper Alarm Report
   e. Power Failure Report
   f. Panel Communications Failure Report

3. Video Management System (VMS):
   a. Video Loss Report
   b. Retention Statistics to include:
      1. Total number of days video images are stored per camera and
      2. Amount of storage consumed per camera per day

4. Intrusion Detection System (IDS):
   a. Communications Failure Report
   b. Verification of successful Ethernet connection to the Central Station
   c. Verification of successful cellular connection to the Central Station

K. The Contractor agrees to indemnify and hold harmless, to the fullest extent of the law, the Owner, the Owner’s Representative and agents and employees from and against any claims, damages, losses and expenses arising from these specifications and associated Contract Documents.

L. There may arise during the bid process a situation where the plans and specifications do not completely agree or coincide with respect to quality, quantities, capacities, compatibilities (hardware, software and/or any combination of those) and costs with other equipment or supporting Contract Documents. In the event such a discrepancy exists, the Bidder shall notify the owner/design professional prior to submitting the proposal or no relief shall be granted after the bid award.

1. So that the matter may be resolved prior to contract award, Bidders should call attention to the matter by citing it in the “exceptions” portion of the submittal, if discovered after the RFI deadline, or in a request for clarification by submission of an RFI, prior to the clarification’s deadline.

M. The Contractor shall consider these plans and specifications as containing confidential information of the Owner and shall not be distributed to persons without a need to know.

1. The Contractor shall ensure that these plans and specifications are kept secure at all times and not copied for any reason unless authorized by the Owner.

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2. The Contractor shall restrict disclosure of specific design information to any other duly assigned and authorized Sub-Contractor personnel who require such disclosure to perform their work under this Contract.

3. ALL electronic copies of sensitive transmitted documents shall be password protected. Passwords shall be provided in a separate transmission.

N. Requests for information (RFI) shall be submitted in writing only. RFIs shall be submitted to the Owner for approval by Technical Maintenance Supervisor in collaboration with Security Directors.

1.04 SUBMITTALS

A. At the time of the bid, the Contractor shall submit electronically the following materials organized with sections identified and segregated as described below. The electronic copy shall be emailed to the Owner's Design Representative. If hard copies are required, the Bidder will be informed of the requirements at the Pre-Bid Conference. The electronic Submittals shall include:

1. TAB 1 - Technical Information

a. The Contractor must acknowledge receipt of all addendums to this RFP in the proposal submission. To accomplish this, bidders shall include a statement similar in intent to “the bidder acknowledges the receipt of addendums one through ‘X’ and considered the information provided in those documents in the preparation of this submittal.

b. Provide a summary of suggested changes (if any) to the bid document floor plans and block diagram indicating the architecture of the proposed system or the relationship between the SMS, IDS and VMS. Changes may be submitted for the sole purpose of increasing system functionality and efficiency or reducing costs; however, changes must maintain the minimum specified requirements and shall be submitted separately from the official bid response price.

c. Manufacturer's product data sheets, catalog pages and descriptions of installed equipment and any special installation procedures to be used for the SMS at the Owner's facility.

1) Data sheets shall be submitted in full color, separated with individual files for each individual item.

   (a) No combined or mass grouping of data sheets is acceptable.

   (b) All data sheets submitted electronically shall have a logical filename describing the product that is represented within the data sheet. The file naming convention shall be developed with the device category first, followed by the manufacturer, then product model number. Example: for a recessed door contact, the filename would be [Door Contact-Nascom-N78B/ST]. For an overhead door contact the filename would be [Door Contact-Nascom-N505A S/ST].

2) Where multiple models or devices exist on one data sheet, a red arrow shall identify the exact model number bid.

3) Model numbers shall include all prefixes and suffixed to positively identify the specific part to be provided.

4) Data sheets submitted during this phase will be accepted during the first submittal phase SSP I.
d. A screen shot image showing the current version of AutoCAD that your design / engineering staff are currently utilizing.

e. A detailed proposed schedule of installation milestones, events, testing and commissioning and turnover for approval by the owner. This should be prepared and submitted in Microsoft® Project® or equivalent graphical representation citing the complete duration of the construction (e.g., should include provisioning for pre-commission testing, performance testing, 30 day trouble-free operation prior to warranty start up). Refer to 280500 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY for project close out requirements.

2. TAB 2 – Pricing and Base Bid information

a. Provide manufacturers’ model numbers, quantities and line-item unit costs for all parts and labor proposed under this project.

b. Provide a base bid and complete proposal per the enclosed proposal instructions on a firm fixed price system installation and complete system turnover basis per project phase. This project may be awarded in whole or in part solely at the Owner’s discretion.

c. Cost Issues:

1) All labor costs, labor hours allotted per device and equipment costs as bid, shall be maintained for 2 years from the date of acceptance of the bidder’s proposal. If manufacturer prices increase the Contractor shall be required to provide documentation of the increase to justify an equipment cost increase. No one-time discounts are allowed.

2) Contractor to provide an hourly rate for work that is performed outside the scope of work defined herein. This will include warranty work on owner provided equipment.

3) A schedule of values as to how the Contractor proposes to invoice the Owner for the project. Note that 10% retainage or more will be held until all punch list items are corrected and closeout conditions are satisfactorily met.

4) A listing of Sub-Contractors proposed for the project and the role of each Sub-Contractor.

3. TAB 3 – Compliance Affirmation

a. The Contractor shall provide a proposal compliance statement indicating bidder’s written agreement with the terms and conditions of the specification.

1) The bidder shall submit a completed certification of compliance statement included as Appendix A to the RFP acknowledging they comply with the terms and conditions contained herein and within the Contract Drawings.

2) The bidder shall list any and all deviations or exceptions to the specification at the bottom of the certification of compliance. Where entries are made, bidders shall provide an explanation as to why he takes exception with the particular requirement and what he proposes as a substitution and why.

4. TAB 4 – Communications and Project Management

a. The Contractor shall provide a description of how the project will be managed based on the following elements:
1) Communications and coordination on planned work on a weekly basis to minimize the Owner’s working environment.

2) Coordination between the sales and technical team to ensure that all of the technical bid documents are in the hands of the installation contract personnel at all times.

3) Progress invoicing per the schedule of values.

4) Plan for management and oversight of subcontractors and coordination with the elevator contractor.

5) Confirmation that the Contractor will provide a conference bridge number for weekly or bi-weekly project look-ahead calls.

6) Contractor’s strategy for staying out in front of project requirements and not allowing project schedule slippage.

7) Coordination of the training and assessing trainee competency.

8) Coordination with the Owner’s IT Department for network security, connectivity, port assignment, accessibility and provisioning of IP addresses.

5. One complete electronic copy of the proposal shall be provided to Enterprise Facility Technical Maintenance Division Supervisor via email.

B. After contract award and prior to purchasing equipment:

1. Pre-Construction Meeting
   a. A pre-construction meeting will be scheduled after the selection of the Contractor.
   b. Items to submit at Pre-Construction Meeting
      1) Contact information for key project personnel (e.g., project manager, engineer, technicians, trainers, Sub-Contractors)
         (i) Name
         (ii) Title
         (iii) Phone number
         (iv) Email address
      2) The pre-construction meeting shall be used at a minimum to revise and fine-tune the project installation, training, commissioning and turnover schedule. The revised schedule shall be due by SSP I submission. Additionally, it shall be used to coordinate with the Owner’s design representative to incorporate Construction Site Review visits by the design representative into the project schedule.

2. Certificate of Insurance (COI) – submit certificates of insurance for the Security Contractor and any sub-contractors hired by the Security Contractor to perform any additional project tasks.

3. The Contractor shall submit product and device samples as requested by the owner.

4. The Contractor shall bear all liability and penalties for damages arising from their failure to submit equipment, cabling and services that meet these Specifications.
Final determination of compliance with these Contract Documents and specifications shall rest with the owner, who, at its discretion, may require proof of performance.

a. Required proof may include, but shall not be limited to, visits by the project manager and other owner representatives to sites where identical equipment is installed and providing use consistent with the intentions of these Contract Documents.

B. **Security Action Submittal Requirements:**

1. Refer to 280500 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY, 1.5 Action Submittals will be uploaded electronically to the project FTP site as directed by the Owner’s representative.

2. Submittals are due within 14 calendar days of the project award.

B. **Security Informational Submittal Requirements:**

1. Refer to 280500 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY, Section 1.6 Informational Submittals.

B. **Security Submittal Package III Submission Requirements, as defined in PART 3 - EXECUTION:**

1. Operations Manuals
2. Installation Manuals
3. Maintenance and first line troubleshooting instructions
4. Record Drawings
5. Record Documents and Electronic Files

1.05 **REFERENCES AND CODE REQUIREMENTS**

A. The Systems shall be installed in accordance with all applicable national, state, provincial, regional and local codes and standards, including, but not limited to the most current issue of the following publications, including all amendments thereto of the issue that is current on the date of the contract award.

B. Where conflicts exist between the Contract Documents and the referenced publications, local codes shall govern. All equipment shall be U.L. listed or meet U.L. requirements for its intended use.

C. Applicable requirements of the following publications shall apply to the work under this specification as if fully written herein.

1. Institute of Electrical and Electronic Engineers (IEEE)
5. Uniform Construction Code (UCC) of the State
6. Americans with Disabilities Act (ADA)
7. Underwriters Laboratories (UL) Applicable Standards for Safety
8. EIA/TIA Standards 569 and 606 (Commercial Building Wiring Standard and Administration Standard for the Telecommunications Infrastructure of Commercial Buildings)
9. National, State, and Municipal Building Codes and all other Authorities having Jurisdiction
10. ANSI C62.41 (surge suppression)
11. Generally accepted good workmanship practices

D. The Contractor is responsible for obtaining copies of any/all documentation listed in this section as well as any standards and requirements set forth by the Owner, which may be referenced.

1.06 COMPLETION

A. The Contractor shall substantially complete the SMS installation according to the Owner’s established target date. Substantially complete is defined as the security system being operational locally.

B. A point-to-point test of all parts of the system will be required for acceptance. System acceptance testing will establish system operability and the warranty commencement date and will be completed and documented by Contractor and an owner representative.

1.07 QUALITY ASSURANCE

A. Installer Qualifications: The successful bidder will be an employer of workers trained and approved by the manufacturer.

1. Work specified herein shall be the responsibility of a single electronic security systems integration Contractor.

2. Contractor shall document a minimum of five years' experience in the fabrication, assembly and installation of systems of similar complexity as specified herein.

   a. This requirement shall apply equally to suppliers and manufacturers of the security subsystems and major components to be used on this project. The documentation shall include the names, locations, and points of contact for at least three installations of the type and complexity specified herein.

3. Materials, devices and/or equipment that are installed, maintained, serviced, programmed, etc. by a single representative due to proprietary equipment and/or manufacturer region exclusive agreements shall not be acceptable. All equipment proposed by the Contractor shall be available through two (2) dealer/installer representatives.

4. The Contractor shall have local in-house drafting and project management capabilities consistent with the requirements of the Work. The Contractor shall provide a dedicated Project Manager who is regularly on-site during times that Work is actively in progress to check progress of the installation and interface with the site point of contact to ensure proper delivery of the scope. This person shall be the same individual throughout the course of the project and shall be the person responsible for system programming, preparation of Operation and Maintenance Manuals, training programs and schedules and test protocols, documentation of system testing, maintenance of Record Documentation and coordination and scheduling of all subcontract labor (as applicable). The owner reserves the right to approve the Contractor’s Project Manager.

5. By submitting a bid, the Contractor thereby certifies that Contractor and Sub-Contractors are qualified in all areas pertaining to, either directly or indirectly, the Work. In the event the Contractor becomes unable to complete the Work in accordance with the Contract Documents, or the satisfaction of the owner or its representatives, due to a lack of understanding of equipment, systems, services or programming ability required by the Contract Documents, it shall be the responsibility of the Contractor to retain the services of the applicable manufacturers' representatives or SME to expeditiously complete the Work in accordance with the Owner's construction schedule with no additional cost to the owner.
6. The Contractor shall have a fully staffed office including a service center capable of providing comprehensive maintenance and service to the security system for the project. The Contractor shall staff the service center with factory trained technicians and adequately equip the office to provide emergency service within four (4) hours after being called, twenty-four (24) hours per day, whether the owner elects to purchase a maintenance contract from the Contractor.

7. The Contractor shall provide manufacturer-certified technicians to install, commission, and maintain the Work. All installation personnel shall be licensed as required by local and/or state jurisdictions. The Contractor shall provide at the time of bid, proof of factory trained and certified technicians for the products being installed. Proof shall be in the form of copies of certificates of the individual technicians who will be assigned to the project. The Contractor shall employ a minimum of one (1) manufacturer trained and certified installation technician and a minimum of two (2) factory trained and certified service technicians. The installation and service technicians required in this section shall be three (3) individuals. Individual technicians who share joint duties for the Contractor shall only be considered to fulfill one (1) of the three (3) required in this section. The Contractor may not utilize Sub-Contractors to fulfill this requirement.

8. The Contractor shall ensure compliance with, and have a thorough understanding of, all local codes and contract conditions pertaining to this project.

1.08 PRODUCT STANDARDS

A. Within 1.01D.6 Appendix E – Approved Security Div. 28 Equipment, for the Security Management System, certain manufacturers have been specified. Refer to 1.02I.1 Substitutions:

B. Provide at the time of installation the latest version of all equipment and software.

1. Discontinued equipment shall not be acceptable.

1.09 DELIVERY, STORAGE, AND HANDLING

A. SMS Hardware

1. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F, and not more than 80 percent relative humidity, non-condensing.

2. Open each container; verify contents against packing list, and file copy of packing list, complete with container identification for inclusion in operation and maintenance data.

3. Mark packing list with designations that have been assigned to materials and equipment for recording in the system labeling schedules that are generated by cable and asset management system specified in Part 2.

4. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

1.10 PROJECT CONDITIONS

A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

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1. Interior, Controlled Environment: System components, installed in temperature-controlled interior environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, non-condensing. NEMA 250, Type 1 enclosure.

2. Interior, Uncontrolled Environment: System components installed in non-temperature-controlled interior environments shall be rated for continuous operation in ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, non-condensing. NEMA 250, Type 4 enclosures.

3. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of minus 30 to plus 122 deg F dry bulbs and 20 to 90 percent relative humidity, condensing.
   a. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph. NEMA 250, Type 4X enclosures.

1.11 TROUBLESHOOTING AND BENCH TESTING

A. The Contractor is responsible for providing system troubleshooting and bench testing as necessary to ensure proof of concept.

B. Failure on the part of the Contractor to provide adequate troubleshooting and bench testing to ensure component compatibility and adhere to the requirements listed below, does not relinquish the responsibility for a complete and operational system nor does it provide a means by which a change order may be issued for troubleshooting or remedial bench testing.

C. If a non-compatibility is suspected, the Contractor shall notify, in writing, the Owner’s Representative and document the following:
   1. Identification of the faulty condition leading to the determination by the Contractor that the components are incompatible.
   2. Documentation from the manufacturer and the Contractor indicating that the incompatibility or issue has been reviewed and that all equipment has up to date firmware and software.
   3. Cost to implement corrective actions or components that correct incompatibilities.
   4. Impact to the installation schedule to implement the changes.
   5. Where components are required to be replaced, submission of component datasheet(s) and approval from the Owner’s Representative is required prior to ordering or implementing the solution.

1.12 WARRANTY

A. The project will not be deemed “complete” until all phases are installed and fully operational, with the final testing completed and the clean-up “punch list” compiled and completion dates assigned to each deficiency. In the event that a sizable punch list develops, at the option of the owner, it may be required that some, or all, unsatisfactory items are corrected prior to final acceptance.

B. The Contractor shall warrant to the Owner that it is the owner of the equipment (provided by the Contractor), and that the equipment will be free and clear of any lien or encumbrance on the final acceptance date.

C. Manufacturer’s software support agreements shall be provided for the first year for all servers and clients. The cost of the support agreements shall be included in the base bid.
D. The Contractor shall provide software and firmware updates automatically in the first warranty year and upon approval of and coordination with the Owner. Then in subsequent years based upon any extended service agreement, if negotiated. These updates shall be accomplished in a timely manner, be fully coordinated and approved by the Owner, and shall be incorporated in the operations and maintenance manuals and software documentation. There shall be at least one scheduled update near the end of the first year’s warranty period, at which time the SMS Contractor shall install and validate the latest released version of the manufacturer’s software.

E. Where the manufacturer’s equipment is warranted by the manufacturer for a period of longer than one year, the additional equipment warranty shall be passed on to the Owner at no additional charge. This information shall be documented in the Warranty Matrix submitted as part of SSP II.

F. The Contractor shall provide all services required and equipment necessary to maintain the entire Systems in an operational state as specified for a period of one year after formal written acceptance of the system and shall provide all necessary material required for performing scheduled adjustments or other nonscheduled work consistent with the guidelines set forth in the MAINTENANCE AND SERVICE section of this specification.

G. The Contractor shall warrant from the final acceptance date agreed by the owner that all security equipment and labor provided in the system(s) will, under normal use and service, be free from defects and faulty workmanship as stated below

1. Power supplies and transformer equipment shall have a three (3) year warranty
2. Warranty coverage will not begin until completion of all of the following three conditions (As long as these three conditions have been satisfied, regardless of the sequence, or whether they overlap, warranty coverage may begin):
   a. When legal ownership of the system has passed to the owner. This will not occur until all portions of the acceptance testing process have been completed and the system has been deemed as “passed.” The point that some devices, or portions of the project, may be powered up for testing, training, burn in, debug or for other purposes, prior to the execution of the acceptance test shall not imply that acceptance or legal ownership has taken place.
   b. Completion and acceptance by the Owner's Representative and/or Owner, of Action, Informational, and Closeout document submissions.
3. The warranty coverage inception date will commence as described above.
   a. Multiple coverage beginning dates or initiating coverage on devices as soon as they are individually installed under the “beneficial use”, or early warranty kickoff claim, will not be permitted.

H. The Contractor's obligation under this warranty is to repair or replace defective equipment, parts, and associated labor thereto at the Contractor's expense.

1. The programming and/or configuration of the repaired or replaced parts is to be performed in concert with the repair and/or replacement of said parts within the contracted warranty period. From the end of the contracted warranty period which includes labor, until the expiration of the manufacturers' warranties, the Contractor will replace that equipment with no additional equipment charges to the Owner.
2. The Contractor shall warrant that replacement or repaired equipment furnished hereunder and labor shall be in accordance with current industry standards.
I. The foregoing warranty does not extend to the equipment or any part thereof which has been subjected by the Owner to unauthorized modification, movement, misuse, neglect, or accident, faulty installation, maintenance, or repairs performed by the Owner or a third party.

1. This applies to Systems equipment used in violation of instructions provided by the Contractor as well as removal, defacement, or alteration of the date of manufacture or manufacturer's serial number.

2. This includes increased or additional warranty service requirements for the equipment resulting from Owner's connection of devices, which are incompatible with the equipment, or to any other external cause not attributable to defects in material or workmanship on the part of Contractor.

J. The Owner shall be granted a nontransferable fully paid license to use all software provided by the Contractor as part of the security equipment under terms established by the software manufacturer.

1. The Owner will be provided with a copy of all applicable licenses and the Contractor shall warrant that it has the right to grant such licenses.

K. Warranty service shall not be assigned or transferred to any agent or other Contractor without prior knowledge being given to the owner not less than fourteen days (14 days) prior to such action.

L. Pre-Warranty Expiration & Test: If this option is exercised by the Owner, prior to the 1-year warranty expiration date the Contractor shall provide a complete system test of ALL devices and software included under this contract, to include the following:

1. Test all SMS workstations for proper functionality and access to all software and hardware components.

2. Test the badging printer, clean badging printer and ensure badges are being printed properly with crisp clean printed images and text and without deformities, color loss or card feed issues.

3. Test card readers for proper read range, function and LED indication of valid and invalid card reads.

4. Test for alarm conditions, held open, forced open, alarms from monitor points.

5. Test for trouble conditions, loss of 120VAC power, loss of battery, power supply fault, fire alarm notification.

6. Locking hardware to include electrified and non-electrified hardware and door closers installed under this contract.

7. Test all VMS workstations for proper functionality and access to all software and hardware components.

8. Ensure desired retention times for video images are being met.

9. Run health monitoring statistics reports to ensure system is performing with optimal operation.

10. Where applicable, initiate an autofocus on the VMS Cameras

11. The Contractor shall conduct this test between months 10 and 11 of the warranty expiration date and shall be complete no later than 15 days prior to the 12-month warranty expiration date.

12. The Contractor shall produce a report to the Owner stating which devices did not pass the test then commence warranty service on defective devices.
13. The requirements of this section shall be a line-item option in the bid submission.

1.13 MAINTENANCE AND SERVICE

A. The Contractor shall provide all services required and equipment necessary to maintain the entire system (s) in an operational state as specified for a period of one year after formal written acceptance of the system and shall provide all necessary material required for performing scheduled adjustments or other nonscheduled work.

B. The adjustment and repair of the system (s) includes all computer equipment, software updates, communications transmission equipment, media converters, encoders, coax to Ethernet converters, wireless transmission equipment or Ethernet switches. Responsibility shall be limited to Contractor installed equipment. Provide the manufacturer's required adjustments and other work as necessary.

C. The Contractor's service personnel shall be qualified to accomplish all work promptly and satisfactorily. The owner shall be advised in writing of the name of the designated service representative, and of any change in personnel.

D. The Contractor shall have and provide a telephone number that is staffed on a 24 hour, 365-day basis or connected to a monitoring location that shall answer that number on a 24 / 365 basis.

E. The owner will initiate service calls when the system (s) is/are not functioning properly.

1. Qualified personnel shall be available to provide service to the complete system (s).

2. The owner shall be furnished with a telephone number where the service supervisor can be reached at all times.

3. Service personnel shall be at the site within four (4) hours after receiving a request for service.

4. The Systems shall be restored to proper operating condition within one (1) calendar day after receiving a request for service. The Contractor shall initiate all service and repair within four (4) hours from receipt of a report of a system malfunction.

F. For the purpose of this contract, failures are defined as follows:

1. Complete failure of the components controlling the system security equipment or interfacing with existing equipment.

2. Complete or partial failure of the panel(s) or workstation(s), resulting in the loss of monitoring or reporting capability.

3. Complete failure of the security equipment, resulting in loss of all system capability.

4. Failure of security equipment, resulting in loss of use of installed cameras of video signal transmission equipment.

5. Performance of scheduled adjustments and repair shall include verification of operation of the VMS as demonstrated by the applicable tests of the performance verification test.
G. All other failures shall be considered minor failures. The Owner will call a designated Contractor-provided telephone number to effect Contractor notification of maintenance problems. The Owner will make reasonable repeat attempts to make notification; however, response time requirements shall be measured from the time of the first attempt by the Owner to notify the Contractor.

H. Repairs - Repair or replacement service throughout the lifecycle of this project and contract shall be performed in accordance with the following parameters:

   a. The Contractor shall maintain and inventory of current security equipment spare parts, materials, consumables and any other system item(s) in order to meet the specified warranty maintenance requirements and keep the security equipment in continuous operational mode during the warranty period. The Contractor shall maintain the latest version of all equipment for warranty replacement purposes. Obsolete or discontinued equipment or parts shall not be acceptable for warranty replacement purposes.

      1. For failures associated with major system components defined as servers, client applications badge printing operations or network connected access control panels, the Contractor's maintenance personnel shall be on-site within four hours from the time the owner reports a system failure.

      b) All failures shall be corrected within eight (8) hours of the arrival of the Contractor's service personnel.

   b. For all other system component failures, the Contractor's maintenance personnel shall be on-site within eight hours from the time the owner reports a system failure if the Contractor is notified between 7 A.M. and 4 P.M. Monday through Friday.

      1. All failures shall be corrected within twenty-four (24) hours of the arrival of the Contractor's maintenance personnel.

I. The Contractor shall keep records and logs of each repair.

   1. A continuous log shall be maintained for the SMS. The log shall contain calibration, failures, repairs made, and programming data.

   2. Complete logs shall be kept and shall be available for inspection on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the Systems.

   3. The Contractor shall separately record each service call request, as received.

   4. The form shall include the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion.

   5. The Contractor shall deliver a record of the work performed within 5 days after work is accomplished.

J. Preventative Maintenance
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1. Preventative maintenance and system testing and inspection activities (as defined in specification section relating to services for years two through five) shall be conducted once between months ten (10) and twelve (12) within the first-year warranty cycle (where this option is exercised) and for each year the Owner wishes to purchase this service for years two through five. This service shall be coordinated and scheduled with the Owner. For the first year, all findings from this system test and inspection shall be addressed as warranty matters with the exception of neglected or accidentally damaged equipment. If the owner contracts with the Contractor for services after year one (1) warranty expiration, these services shall be coordinated with the Owner at the beginning of each service year or as otherwise agreed.

2. After each annual test and inspection, all test results for each door and device shall be documented (indicating pass, fail and if failures are reported, the exact deficiency) and supported by SMS output event reports.

3. Leave proof of service.

4. The Contractor shall prepare an estimate of costs to repair any deficiencies discovered in the course of the test during years two through five.

5. The Contractor shall make recommendations for system modification in writing to the Owner. No system modifications, including operating parameters and control settings shall be made without prior approval of the Owner. Modifications made to the systems shall be incorporated into the operations and maintenance manuals and other affected documentation.

6. Maintenance and repair service (post warranty) shall not be assigned or transferred to any agent or other Contractor without prior knowledge being given to the owner not less than fourteen days (14 days) prior to such action.
PART 2.00 - PRODUCTS

2.01 SMS PRODUCT STANDARDS Similar to Part 2 of 280500 COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY, Part 2 of 281300 ACCESS CONTROL/INTRUSION DETECTION SYSTEM, and Part 2 of 282300 VIDEO SURVEILLANCE SYSTEM

A. Refer to Appendix E – Approved Security Div. 28 Equipment

B. The Owner’s Representative shall approve all product submissions prior to ordering of products. The Security Contractor shall bear all responsibility for product rejections and/or changes required as part of the submittal process if products are ordered prior to approval.

C. All substitutions shall meet or exceed the minimum functional and technical specifications. Acceptance of such substitutions is at the discretion of the Owner. For those manufacturers listed as “Manufacturers” the Contractor shall submit products from one of the manufacturers listed.

D. Units of the same type of equipment shall be products of a single manufacturer. All materials and equipment shall be new and currently in production. Each major component of equipment shall have the manufacturer's model and serial number in a conspicuous place. All parts, other than small hardware items and fittings, but not including locks, latches, strikes, card readers, etc., shall be of the same model throughout the course of this project.

E. Not all products or devices listed in Appendix E – Approved Security Div. 28 Equipment may be part of the scope of this project.

F. The requirements contained herein may supersede manufacturers’ instructions or supplied hardware. Where this exists, this specification shall take precedent above the manufacturers’ instructions and/or hardware.

2.02 FIBER OPTIC EQUIPMENT

A. Refer to Division - 270000 – Froedtert Health Telecommunications Standards as required.

2.03 NETWORK EQUIPMENT

A. Refer to Division - 270000 – Froedtert Health Telecommunications Standards as required.

2.04 NETWORK PATCH CABLES

A. Refer to Division - 270000 – Froedtert Health Telecommunications Standards as required.

2.05 WIRE AND CABLE

A. Refer to Division - 270000 – Froedtert Health Telecommunications Standards as required.

B. Where composite wiring is required elsewhere in this specification, the composite cable shall be of the OSDP composite type with the following elements contained under an Orange overall outer jacket: Preferred composite cable part# Windy City - WCW-4461040-OSDP

1. A - Reader Communications - Low cap minimum 22/4AWG shielded for RS485/OSDP with 120 ohm impedance and capacitance of 10.8 pF/ft.

2. B - Reader Power - 18/2AWG non-shielded (ns)

3. C - Door contact - 22/4AWG ns

4. D - REX Devices - 22/4AWG ns

5. E - Locking devices - 18/4AWG ns

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Note: the individual elements do not have to be orange.

PART 3.00 – EXECUTION - This section expands on the Part 3 sections of 280011, 280500, 281300, and 282300.

3.01 GENERAL

A. The Contractor shall install all proposed Systems components in accordance with the manufacturers’ instructions either printed or verbal, and as shown on the Contract Drawings. Furnish all necessary interconnections, programming, services, and adjustments required for a complete and operable System as specified and shown during each phase of construction as shown on the Contract Drawings.

B. Project Communications and Correspondence:

1. To support construction meetings, the Contractor shall provide a conference call line or virtual format such as GoToMeeting or MS Teams and shall conduct the meetings.

2. The Contractor shall track, compile and distribute meeting minutes from each construction meeting in a format provided at project commencement. Meeting minutes shall be distributed no more than two business days after the conclusion of the meeting.

3. Meeting minutes shall be emailed to project team members as a PDF attachment to an email dedicated to the meeting minutes. Meeting minutes shall not be attached to meeting invites.

4. The meeting minutes shall include the following information:
   a) Project name, Owner’s name / logo, Installing Dealer’s name / logo, Owner’s Design Representative name / logo.
   b) Project managers and/or primary point of contact from each company listed above.
   c) Meeting number, date, start time and location.
   d) Next meeting date and time.
   e) Meeting call number and code if required to access the meeting.
   f) Meeting attendees including attendee’s email address and cell phone number.
   g) A logical listing of project topics. For example, entries for Project Milestones, Administrative Matters, Installation Progress, Training, Change Orders etc.
   h) The date that the topic was first brought up or entered into the meeting minutes.
   i) Who is responsible for resolving the issue and when it is due.
   j) An indicator of when things are complete, due, overdue or causing an issue.

5. If the Contractor would like a template for the purpose of keeping the meeting minutes, they may request one from the Owner’s Representative.

6. Meetings shall be conducted on a weekly or bi-weekly schedule as determined by the Owner or the Owner’s Representative.

7. The Contractor shall send out a recurring calendar invite corresponding to the meeting schedule as determined by the Owner’s Representative. The invite for the meeting shall include:
   a) Time and date of the meeting.
   b) Meeting location or use “Respective Location”.

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c) Phone number for the meeting.

d) Meeting access code.

e) One (1) hour meeting reminder prior to the meeting start time.

C. In the event the Contractor notes any condition that affects or potentially could affect the performance of the systems, the Contractor shall submit a report to the Owner documenting any changes to the site or conditions. Failure of the Contractor to become familiar with the site conditions prior to the SSP I project stage shall not relieve the Contractor of responsibility for full completion of the work in accordance with the contractual provisions of these Contract Documents.

D. At the SSP I project phase; the Contractor shall inspect locations where installation work will be performed and verify that conditions found are in accordance with the Contract Documents and are acceptable for the Contractor's installation work. Report any discrepancies in writing to the architect, stating suggested means of correction.

1. Change orders for field conditions which vary from those represented during the bidding portion of the project, and which should have been discovered during the inspection described in the preceding subsection are not likely to be allowed.

E. Specific device mounting locations, precise wire and cable runs, and any conduit routing have not been specified in the Contract Drawings. Coordinate all aspects of installation and ensure that adequate conduit is provided, that equipment backboxes are adequate for system installation, that power has been provided and properly located and that doors and door frames are properly prepared for door hardware.

F. The Contractor shall check all power and communications cabling for continuity before making connections.

G. Coordinate all card readers and request-to-exit device-mounting locations with the Owner's Representative prior to installation.

H. All devices shall be manufactured of materials and durability for the environment in which it is to be installed.

I. The Contractor shall coordinate finishes and colors of all equipment with the Owner. Locking devices shall be coordinated to match the existing door hardware at each door location where new locking hardware will be installed.

J. Specification & Contract Documentation

1. The Contractor shall keep on the job, at all times, and in the possession of the tradesmen performing the work, a copy of these specifications and all project drawings, including the approved wire path prints.

   a) Should the owner, or a representative of the owner make a site visit and request to see these documents and they are not available, work may be stopped until the documents are obtained.

2. Wherever work is installed otherwise than as shown on the Contract Drawings, such changes shall be noted.

K. Tobacco and seed use:

1. Contractor to follow all vendor compliance rules.

L. Construction Site Visits:
Security Management System

January 2024

1. The Construction Site Visit is intended to check on the progress of the installation and allow the Owner’s Design Representative and/or the Owner an opportunity to identify, potentially, any issues with the installation that do not fall within the requirements of this specification, industry best practices or a neat and workman like manner.

2. The Construction Site Visit will be performed on-site and may encompass checks on all aspects of the installation to date. This visit may also validate other requirements based on the progress of the installation as required within this specification such as current redline drawings/field markups.

3. Construction Site Visits will be conducted monthly for projects lasting greater than one month. For projects where the bulk of the installation is performed within a month’s time, two construction site visits may take place.

4. For the purpose of the site visit, the Security Contractor shall make available the representative of said Contractor with the greatest knowledge of the installation, any coordination or installation issues and the overall project progress. This would typically be the site foreman or site supervisor but may also be the Security Contractor’s Project Manager if that individual has the information required herein.

5. Construction Site Visits may require 2-8 hours based on the scope of the project and the number of items to be reviewed.

6. The Security Contractor is responsible for the inclusion of any time required by their representative for the Construction Site Visit and will not be able to submit a change order for this work.

3.02 IT / NETWORK SECURITY AND COORDINATION

A. The Contractor shall coordinate any/all network connections with the Owner’s IT department prior to making any physical connections to the Owner’s network components. Failure to follow this directive may result in expenditures for repair and troubleshooting by the Owner’s IT department or 3rd party IT contractor/vendor. Such expenditures to remedy any issues caused by incorrect coordination by the Contractor shall be borne by the Contractor.

B. The cost of investigation, repairs and reprogramming resulting from any security breaches during construction or operation of the system (while under warranty or service agreement) attributable to the failure of the Contractor to implement approved IT security measures shall be borne by the Contractor.

C. Security of Devices: Many IP devices do not have the ability for their default usernames to be changed on the administrator account but do have the ability to have the password changed. As an alternative to utilizing the administrator account for login and communications to the server, an additional user account may be setup that will allow for a unique username to be utilized. This account can also be set up to limit functionality of the login when using this account. However, it is also understood that some VMS Servers require that the administration account be utilized for their connections and for this reason, the administrator account may need to be used.

D. Recommended Measures: The following are recommendations for securing devices. Wherever possible, the highest level of security should be utilized:

1. IP Cameras, Panels and other IP devices:
   a) Set a Security Protocol using – in order of preference from highest to lowest.
      (1) HTTPS
      (2) Digest Authentication on HTTP
      (3) Basic Authentication
3.03 EQUIPMENT SETUP AND PROGRAMMING

A. The following section defines the parameters by which the electronic and electromechanical equipment shall be set up and/or programmed for each device within the system. These parameters shall be programmed into each door location for the entire system. **Note: There may be certain situations where these parameters may not be practical for a given application. One such situation would be an extended hold open time. Slight adjustments may be required based on actual site conditions and the Contractor will be responsible for adjustments through the commissioning process at no additional cost to the project.**

B. General Conditions:
1. The Contractor shall coordinate with the Owner, enter and program all data needed to make the system operational.
2. Naming conventions for all portals and other security devices covered under this project will be established in the Termination Schedules provided within the Contract Drawing Package. Refer to TY300 Termination Schedule. These names shall be used throughout the life of the project, including for all programming into the SMS software and IDS controllers. Security Contractor to follow Froedtert standard naming convention found in “FH Genetec Matrix” document which can be provided by Technical Maintenance Division.
3. The Contractor shall identify and request any additional data needed to provide a complete and operational security system.
4. The completed forms shall be delivered to the Owner for review and approval at least 21 days prior to the Contractor's scheduled need date in SSP II.
5. If the Contractor is lacking any portion of the information to complete any assigned system programming, a Request for Information (RFI) shall be transmitted prior to commencing any programming.
   a) Incorrect programming and device naming will be required to be corrected by the Contractor, at no expense to the owner.
   b) A statement by the Contractor that not all information was made available, in the event of inaccurate programming, will not be an acceptable defense.
6. Programming shall include, but not be limited to, elimination of duplicate or redundant information, synchronization of system clocks, camera sequences, dome presets, salvos and tours as appropriate.

C. Databases:
1. All database work to be coordinated with Froedtert IT Business Applications.

D. Networks and network connected equipment:
1. All Froedtert IT Network Manager.

E. Usernames and passwords for security equipment installed under this scope:
1. All username and passwords to follow Froedtert password outline.
   a) Passwords must:
      (1) Have at least 12 characters
(2) Not contain your name or login account

b) Password must meet three of four criteria
   (1) English uppercase character (A through Z)
   (2) English lowercase character (a through z)
   (3) Numbers (0 through 9)
   (4) Non-alphabetic character (for example !, $, #, %)

2. Prior to reprogramming, all username and password changes shall be submitted for review to the Owner, Owner’s Representative and/or the Owner’s IT resource for approval with the SSP II Submittal. Where changes are needed the Contractor shall provide these changes as part of the review/approval process at no additional cost to the project.

3. If the contractor fails to adhere to this procedure and prematurely re-programs usernames and passwords and a change is needed thereafter, the Contractor shall provide those changes at no additional cost to the project.

F. Access control panel hardware:
   1. Access control hardware shall be installed within enclosures as shown on the Contract Drawings. Any design variations shall be submitted to the Owner’s Design Representative for review. Simply submitting a design variation is not acceptance of the variation by the Owner’s Design Representative.
   2. Failure to follow the Contract Drawings will result in the Contractor taking corrective actions at their own cost to bring enclosure layouts back in alignment with the Contract Drawings.
   3. Mercury hardware intelligent controllers, reader boards, input boards and output boards shall be powered from the 24vdc source.
   4. The contractor will place asset tags on the access control enclosure. The asset tags will be provided by the Owners Representative

G. Termination Schedules:
   1. Field wiring shall be terminated at the access control panel hardware as shown on the Terminations Schedules contained within the Contract Drawings.
   2. Failure to follow these schedules may result in the Contractor taking corrective action at their own expense to bring wiring terminations back in alignment with the Contract Drawings.
   3. Any additions to the Termination Schedules shall be captured during the Record Drawing process.

H. Card Readers:
   1. Card readers shall be powered from the reader board voltage source that is on the same connection where the data and LED control is terminated. Exception: Power for long range readers requiring a separate power source shall not be terminated on the same connector as the data and LED control terminations but shall have the negative of the separate power source and the negative of the reader power source connected in parallel to create a common reference point.
   2. The readers shall be OSDP connected using SCP and SCP reader boards.
   3. The reader LED shall be RED at times during a door locked condition and where no card is present within the reader field. This will be considered the normal state.
4. When in an auto-unlock mode, timed unlock or a valid unlock is initiated from a client application, the reader LED shall turn green for the interval of time by which the lock is released or the expiration of the unlock time if the door is not opened during the unlock sequence.

5. When a valid card is read at the door, the reader LED shall flash RED-GREEN-RED-GREEN for the duration of the unlock time or the door is opened. During this condition the reader beeper shall beep once for approximately 1 second.

6. When an invalid card is read, the reader LED shall extinguish then light solid RED for several seconds at which point it will again extinguish then return back to a normal state. During this condition the reader beeper shall sound once for approximately 3 seconds.

7. During an alarm condition, either Forced or Held open, the reader LED shall flash RED-GREEN-RED-GREEN for the duration of the alarm condition. Once the door is closed, the reader LED shall return to a normal state.

8. Pre-alert timing by use of the reader beeper. Pre-alert timing shall be set to 25 seconds after the door opens, in advance of the Hold Open alarm. Note: This is a baseline timing parameter. Actual locking arrangements, door use and environment may dictate an adjustment to this parameter after an initial use period determines patterns of use. It is expected that the Security Contractor will perform these adjustments as required at no additional cost to the project.
   a) Pre-alert timing shall be reset by either closing the door, tripping the REX or a valid card read.
   b) While the door is open, any reset by means of a REX trip or valid card read, the pre-alert beeper shall continue to sound but will reset the pre-alert timer to 25 seconds. This sequence shall continue until the door is closed.
   c) The reader beeping shall sound in an approximate one second on, one second off interval for the duration the pre-alert.
   d) During any alarm condition, the reader beeper shall sound in an approximate ½ second on, ½ second off interval then repeat until the alarm condition is cleared.
   e) The closing of the door shall silence the reader beeper.
   f) If the door goes into a full alarm condition the reader beeper shall continue to sound until the door is closed.

9. A door forced open alarm shall also activate the reader beeper.

10. Reader tampers: the reader tamper indicator shall be programmed and enabled to detect removal of the reader from the wall. The reader tamper shall be programmed to create a visual and audible alarm condition on the SMS system-monitoring screen and send out an alarm message via Text Message or Email to the System Administrator.

I. Privacy Locks on Wellness Room Doors:
   1. Where indicated on the Contract Drawings, Wellness rooms shall be fitted with a special electrified mortise lock with an outside privacy indicator and thumb-turn deadbolt on the interior.
   2. Activation of the deadbolt shall prevent a valid card from unlocking the door. This shall be accomplished by the following means:
   3. The thumb-turn shall activate a switch within the lock.
      a) The switch shall be wired to the SMS as an input point.
b) The input point shall be programmed to:
   (1) Disable the card reader and
   (2) Turn the card reader LED a color other than red or green. *Note: blue is preferred but it is understood that some SMS manufacturers are incapable of the controls required to turn a reader LED blue.*

J. Door Contacts:
   1. Shall be programmed for a 45 second hold open time. *Note: This is a baseline timing parameter. Actual locking arrangements, door use and environment may dictate an adjustment to this parameter after an initial use period determines patterns of use. It is expected that the Security Contractor will perform these adjustments as required at no additional cost to the project.*
   2. Forced and Held Open alarm conditions shall sound the reader beeper as described above.

K. Request to Exit (REX) devices:
   1. There are two types of request-to-exit devices for most door locations and will be noted as such on the Contract Drawings: PIR and RX switch lever/exit panic device.
   2. For the RX switch:
      a) Any door with an RX switch shall be wired in a closed loop in conjunction with the closed loop of the PIR REX locally at the door, then one circuit shall be connected to the REX input at the panel as designated on the Termination Schedules.
   3. For the PIR REX:
      a) Shall be set for a timer trip of 0.5 seconds.
      b) Shall have its trip timer be set for non-resettable.
      c) Shall be angled at approximately a 30-degree angle from the wall of the door in which the REX device is associated with. *Note: This is a baseline parameter. Actual locking arrangements, door use and environment may dictate an adjustment to this parameter after an initial use period determines patterns of use. It is expected that the Security Contractor will perform these adjustments as required at no additional cost to the project.*
      d) The REX device shall be powered from a 24vdc power source. Alternative voltages may be acceptable but only by written approval of a formal request from the Contractor, outlining the specific reason why.
      e) The REX shall be wall mounted on the centerline of the opening approximately 6"-12" above the top of the opening.

L. Electro-mechanical locking devices:
   1. Shall be programmed for a 5 second unlock time.
   2. Shall be programmed to automatically relock upon the door opening.

M. Desk Mounted Event Devices:
   1. Event buttons shall be mounted in a discrete location under the desktop or counter surface where the person utilizing the space is typically positioned so that the device can be discretely activated by the person attending the workstation. Technicians shall confirm the working position of the effected person prior to installing the device.
2. Shall be installed flush with the front edge of the desk or counter surface.

3. If a mounting spacer is required to facilitate the mounting requirements herein, the Contractor shall provide the spacer.

4. Shall be programmed to annunciate activation signals as alarm Event at the Security Command Center (or similar) client station at the highest priority allowable within the software.

5. Reset keys shall not be left in the Event device once installed. ALL reset keys shall be handed over to the Owner at the time of completion.

N. Wall Mounted Event Buttons:
   1. Wall mounted Event buttons shall be installed in locations as shown on the Contract Drawings.
   2. The wall mounted Event shall be a latching type of device fitted with a key-only reset mechanism.
   3. Reset keys shall not be left in the Event device once installed. ALL reset keys shall be handed over to the Owner at the time of completion.

O. CFA Stations:
   1. Shall be programmed to call a specific primary number within the SOC.
   2. Shall be programmed to call a specific secondary number if the primary number does not answer or if the line is busy.
   3. Shall be programmed to call a specific tertiary number if the secondary number does not answer or if the line is busy.
   4. Shall be programmed to integrate into the VMS for camera call up of the integrated faceplate camera.

P. Sounders (where used):
   1. Any door equipped with a sounder shall be wired and programmed to sound during any alarm condition generated at the respective door location.
   2. Restoral of the alarm condition by closing the door shall silence the sounder.
   3. Sounders shall be connected so that in the event of a fire alarm, power to the sounder circuit will be interrupted.

Q. Batteries:
   1. Batteries shall be housed in appropriately size 8” x 8” x 18”, 24” or 36” electrical metallic wireway trough as shown within the Contract Drawings.
   2. Battery troughs shall have tamper switches per the requirements of this specification.
   3. Electrical troughs shall have end caps installed prior to mounting on the wall.
   4. Batteries shall be wired with a minimum of #14AWG THHN wire.
   5. Battery wiring shall utilize red conductors for positive connections and black conductors for negative connections.
   6. Conductors shall be bundled by battery or battery group where in series for 24vdc sources.

R. Tamper Switches:
   1. Regardless of system or connection, the tamper switch input shall be programmed to generate an alarm condition upon activation of the tamper switch.
2. The alarm condition shall be programmed to create a visual and audible alarm condition on the SMS system-monitoring screen and send out an alarm message via Text Message and Email to the System Administrator.

3. Tamper Switches for the following devices shall be monitored:
   a) All system enclosures
   b) All card readers
   c) All VMS cameras

S. Video Intercom:
   1. Each video intercom door station shall be programmed to call a specific video intercom master station as indicated on the Contract Drawings. This is the Primary Video Intercom Master.
   2. In addition, if the call is not answered on the Primary Video Intercom Master, each video intercom door station shall be programmed to roll over Secondary Video Intercom Master station as indicated within the Contract Drawings.
   3. Shall be programmed along with the SMS to allow release of the door associated with the respective door station.
   4. Release shall be by means of an IP addressable relay output module. For each door with a video intercom door station, one output of the module shall be connected to an independent SMS input and programmed for a valid unlock. The input to which the output is connected shall reside on the same reader board that controls the door to be released.
   5. Under no circumstance shall the release circuit be connected to the REX or the REX input.
   6. Shall be programmed to send out up to three emails if the call is not answered at the master or sub-master(s) stations.

T. VMS Cameras:
   1. Each installed camera shall have its factory default username and password changed at the time of startup and prior to Commissioning.
   2. Initial PTZ home positions and presets as noted.
   3. Initial view setup, camera sequences, tours and salvos.
   4. New IP Video cameras shall be setup with video motion detection zones where specified in the camera schedule.
   5. The username and password shall be coordinated with the Owner and handed over to the Owner as part of the record documentation process.

U. Time synchronization for VMS:
   1. The NVR shall be connected to the client’s domain where it will pick up its network time & date stamp.
   2. All VMS cameras shall be configured to receive their time & date stamp from the NVR.

V. UPS:
   1. Where UPS devices are furnished under this scope, the following shall apply:
2. Where a server or servers are connected to a UPS, the UPS and server or servers shall be connected to allow the server or servers to perform an orderly shutdown in the event of an extended power outage.

3. Interconnectivity may be by Ethernet, USB or serial connectivity. Note: It is understood that in most cases, a software application will also need to be loaded onto any servers that are to be shut down. This shall be part of the scope where a UPS is installed.

4. For 120VAC power loss:
   a) An output from the UPS shall be setup and programmed to transfer contacts in the event of a power failure to the UPS.
   b) The UPS output contact shall be connected to an alarm input of the SMS or camera nearest to the UPS location.
   c) The camera input shall be programmed to generate an alarm condition upon activation from the UPS loss of power output connection. The alarm condition shall be programmed to create a visual alarm condition on the SMS system-monitoring screen and send out an alarm message via Text Message or Email to the System Administrator.

3.04 ELEVATOR CONTROLS
A. Where floor or cab call readers controls are installed as part of this scope, they shall be connected to the same access control panel and control board that provided the output control closures to the elevator equipment interface.

B. Where output boards are required to fulfill the needs of individual floor controls, it is understood that these boards do not have reader port connections. However, the output boards shall be connected to the same intelligent controller that is also controlling the reader boards to which the elevator readers are connected.

3.05 POWER AND POWER MATTERS – Refer to division – 260000.
A. The Contractor shall provide the necessary power supplies for all panels and field devices provided in this project.

B. No more than two full panel elevation stacks shall be powered from one 20A circuit.

C. All panels to be cord and plug with the use of a locking cover at the receptacle.

3.06 WORKMANSHIP AND INSTALLATION REQUIREMENTS
A. GENERAL
   1. Deliver and store materials in manufacturers’ original packaging labeled to show name, brand, type and grade. Store materials in protected dry location off ground in accordance with manufacturer’s instructions.
   2. Infection Control
      a) Refer to Froedtert Hospital Infection Control Risk Assessment Matrix.
   3. Install Systems in accordance with manufacturer’s recommendations.
   4. The entire work provided by the Contractor in this Specification shall be constructed and finished in every respect in a workmanlike and substantial manner.
5. It is not intended that the Contract Drawings shall show every installation support device, screw, pipe, fitting or fixture associated with installation and operation.

6. The Contractor shall furnish and install all parts as may be necessary to complete the Systems in accordance with the best trade practice and to the satisfaction of the Owner and/or architect.

7. The Contractor shall keep other Sub-Contractors fully informed as to shape, size and position of all openings required for his equipment and shall give full information to the architect and other Sub-Contractors sufficiently in advance of the work so that all openings may be built in advance.

8. In the case of failure on the part of the Contractor to give proper notice and timely information as noted above, the Contractor shall do his own cutting and patching or have the same done by another Sub-Contractor, but in any case, without expense to the project.

9. The Contractor shall obtain detailed information from the manufacturers of equipment as to the proper method of installation and connecting same. He shall also obtain all information from the owner and the other Sub-Contractors that may be necessary to facilitate his work and the completion of the whole project.

10. Remove daily to a centrally designated location on each site all rubbish and debris and all refuse from workmen’s lunches and at completion, remove all surplus materials, temporary works and leave all work in clean condition, acceptable to the owner.
   a) All bare floor or tiled office, residential and corridor spaces shall be broom clean each night.
   b) If carpeted, all areas in which work occurred on any given day will be vacuumed each night.

11. No chemical may be brought on owner property, whether in the performance of this project or not, without being accompanied by the proper and current SDS.
   a) No hazardous materials or chemicals will be left unsecure or unattended at any time.

12. The Contractor is responsible for providing all tools, materials, equipment, workmen and labor to successfully complete the project, without any assistance from owner resources UON.

13. No direct burial cable shall be directly buried in the ground or below finished surfaces for any part of the installation unless it is installed within a conduit. Exception: Wiring loops cut into roadways, driveways or similar surfaces for the purpose of detection of vehicles for a gate or barrier arm entry, exit or safety system are allowed to be directly buried in the surface without the use of a conduit.

14. No junction box or equipment enclosure requiring access shall be installed above finished ceilings.

15. The installing vendor is responsible for making all requests for stakeouts and utility mapping prior to the initiation of any excavations and shall ensure that all applicable parties suitably respond prior to any excavation. To be considered as included within the parameters of this subsection are requests for the movement of overhead or underground utilities, as well as the sleeving of any appropriate electrical conductors.
   a) Notifications made without waiting for a corresponding utility response will not be considered a defense in the case of damaged utilities and disrupted services.

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b) Any firm or entity damaging or interrupting any utility or service shall be responsible for the full cost of repairs and interruption of services costs.

16. Arrange all components to be mounted in the rack(s), or on a wall in accordance with the Contract Drawings.
   a) Where insufficient information exists for this task, the Contractor shall submit a written RFI to clarify the work needed.
   b) The design shall provide a neat appearance and accessibility for servicing equipment.

17. Control signal, communications, and data transmission line grounding shall be installed as necessary to preclude ground loops, noise, and surges from adversely affecting system operation. Provide mounting hardware as required.

18. The Security Contractor shall install the security equipment in accordance with the appropriate installation manual for each equipment type. Components within the system shall be configured with appropriate service points to pinpoint system trouble in less than 20 minutes.

19. All wiring, including low voltage wiring, cabinets, boxes, and similar enclosures shall be plenum rated.

20. All fasteners and washers used in exterior, wet or damp locations shall be manufactured from stainless steel. This includes where drop-in style anchors are utilized. Where a piece of equipment is provided, with fasteners, from the manufacturer, and they are not manufactured from stainless steel, they shall be replaced with stainless steel fasteners. Fasteners shall be defined as, screws, nuts, bolts, washers of any type, lag bolts, lag screws, screw eyes, sheet metal screws, wood screws and machine screws. Exceptions: J-bots and/or anchor bolts embedded/captive in poured concrete for the purpose of mounting poles, stanchions or other similar structures may be manufactured from steel but shall be hot dipped galvanized (HDG).

21. All inputs shall be protected against surges induced on device wiring. Outputs shall be protected against surges induced on control and device wiring installed outdoors.

22. All communications equipment shall be protected against surges induced on any communications circuit. All cables and conductors, except fiber optics, shall have surge protection circuits installed.

23. Inspect each component, determine obvious defects, if any, and correct.

24. Perform tests as recommended by manufacturer or as required to ensure the security equipment is operating properly and meets specified requirements.
   a) Where there are technical irregularities in system performance, Contractor shall be responsible for contacting the manufacturers or their representatives for initial troubleshooting.
   b) Correct all deficiencies detected and retest affected components.

25. Record test data, tabulate, and write narrative describing tests, results, deficiencies found, corrective measures, and results of retesting. Certify to the Owner that the security equipment has been tested and is ready for performance verification testing and project close out as part of the closeout requirements.

26. All equipment installed under this scope shall be installed in a neat and workman like manner.
B. ENCLOSURES AND EQUIPMENT RACKS – REFER TO DIVISION - 260000 and 270000
C. JUNCTION BOXES, CONDUIT BODIES AND RACEWAYS REFER TO DIVISION - 260000
D. GROUNDING OF TVSS, EQUIPMENT RACKS AND ENCLOSURES – REFER TO DIVISION – 260000 and 270000
E. WIRE INSTALLATION & OTHER WIRING MATTERS – REFER TO DIVISION – 260000 and 270000.
F. LABELING - REFER TO DIVISION - 260553
A. FIRESTOPPING – REFER TO DIVISION - 078413
G. SURFACE RESTORATION – REFER TO DIVISION - 280500 - COMMON WORK RESULTS

3.07 TRAINING
A. The Contractor shall conduct training courses for designated Owner personnel in the maintenance and operation of the Systems as specified. The training shall be oriented to the specific systems being installed under this contract.
B. A task driven competency assessment (involving some hands-on work with the system(s)) will be given to all students during which they should be able to correctly perform the required tasks. During the test, student generated notes and "cheat sheets" will be permitted. Similar materials and manuals provided by the trainer will also be allowed.
C. The trainer shall provide a comprehensive training manual for use during the class sessions which shall detail the tasks necessary in the operation of the system, their purpose and the background regarding when and why they are necessary, as well as the step-by-step procedure to be followed to complete each task.
   1. Training manuals shall be delivered for each trainee with two additional copies delivered for archiving at the project site.
   2. When presentations, such as Microsoft® Power Point®, are utilized for training purposes a copy of the presentation shall be provided to the students.
   3. When presentations are printed from a presentation set of slides, the printed materials shall be completely legible. Multiple features of text and graphics shall not be overlaid on top of each other when printed.
   4. Training manuals shall be printed single sided in color.
D. A manufacturer operation manual shall be delivered for each trainee with two additional copies delivered for archiving at the project site. These manuals shall be printed doubled sided and in color.
E. UON, the Contractor shall prepare, administer and conduct a training program for designated Owner operator personnel to fully and efficiently operate the installed SMS and maintain the configurable databases. At a minimum, the following training elements shall be incorporated into the training program and documented separately for individual training segments:
   1. Access Control Training:
      a) Logging into the System.
      b) Adding and deleting users for the system software.
c) Adding and deleting cards from the system.
   (1) Differentiating between employee and non-employee card / badge design.

d) Adding, modifying and assignment of:
   (1) Access Levels
   (2) Time Zones
   (3) Holiday Schedules

e) Creation of badges
   (1) Taking badge photos
   (2) Saving badge photos
   (3) Setting up printer
   (4) Getting printer ready for printing badges
   (5) Loading the printer with cards
   (6) Cleaning the printer
   (7) Changing ribbons

f) Running activity reports on a card holder or door – trace

g) Access Control Reports:
   (1) Active credentials report
      (a) A review indicates that no separated employees have active access credentials in the cardholder database.
      (b) Verify that there is only a single credential issued to any one person.
      (c) Verify that there are no generic name badges issued and if so, do a physical inspection to ensure card can be located.
   (2) Forced door alarms
      (a) Identify conditions, look for trends indicating improper behaviors or system problems.
      (b) Identify high offending doors and investigate
   (3) Access Level
      (a) Verify that access levels are being appropriately assigned that provides the minimum level of access consistent with a cardholder’s needs versus everyone having all doors 24x7.
   (4) System User Report
      (a) Verify Administrator privileges are not assigned to all users, particularly non-employees.
      (b) Confirm that no two people are sharing log-on credentials.
      (c) Confirm that only authorized users have credentials to log into the system.
(5) Access denied reports
(6) Exporting of reports in CSV and TXT formats

h) Launch of main alarm monitor.
i) Masking and unmasking alarms
j) Remote release of door or changing status of a door; put a door into access mode for a period of time or locking out a reader/door completely.
k) Ensuring all system server services are running and setup to startup after a reboot or power failure.
l) Documentation and getting additional help with the system’s help menus.
m) First line troubleshooting techniques to determine cause of failure or malfunctioning system software or hardware devices.
n) System backups
   (1) Full
   (2) Differential
   (3) Frequency
o) System restorals from a backup

2. Video Management System Training:
a) Logging into the System.
b) Adding and deleting users for the system software.
   (1) System User Report
      (a) Verify Administrator privileges are not assigned to all users, particularly non-employees.
      (b) Confirm that no two people are sharing log-on credentials.
      (c) Confirm that only authorized users have credentials to log into the system.
   (2) Exporting of reports in CSV and TXT formats
c) Launch of main viewing monitor.
d) Changing recording parameters
e) Changing video motion detection fields
f) Searching for video
g) Exporting video
h) Creating a video report
i) Documentation and getting additional help with the system’s help menus.
j) First line troubleshooting techniques to determine cause of failure or malfunctioning system software or hardware devices.
k) System back up and restoration.
3. Intrusion Detection System Training:
   a) Overall system explanation including SMS integration:
      (1) Zones
      (2) Bypass
      (3) Entry/Exit Zone and timing
   b) Keypad functions
      (1) Arming and disarming the system
      (2) Bypassing a zone
   c) Interfacing with the Central Station
      (1) Response & Dispatch protocols

F. The training venue shall be set up with a sufficient number of workstations so that each workstation has no more than two students assigned to it.

G. All workstations must be fully populated with all options and features of the software being presented.

H. The trainer shall have a workstation of his own, which should have a projector attached so that as he moves throughout the program, he is able to demonstrate to the students exactly where menu choices and similar items are, as he describes and talks the students through them.

I. The Contractor shall provide and use all training aids such as films, slides, audio/video tapes, etc. as necessary to complement instruction and enhance learning.

J. The instructor(s) shall be responsible for determining the appropriate password to be issued to the student commensurate with each trainee’s acquired skills at the beginning of each of these individual training sessions.

K. Training shall be provided for the topics and periods indicated herein at least one week prior to the scheduled turnover to the Owner of the system. Upon completion of training, each trainee, using appropriate documentation, should be able to perform elementary operations with guidance and describe the general hardware architecture and functionality of the system.

L. The Contractor shall provide a competency assessment at the conclusion of the training.

M. The Contractor shall provide lesson plans in advance of conducting any training as part of SSP II. The Owner’s Representative may conduct independent competency verification and the failure of system users to properly demonstrate basic competency will result in a requirement for Contractor retraining of Owner’s personnel.

N. Training sessions shall be fulfilled with the following minimum requirements:

1. Initial Administrator Training – six (6) hours for a maximum of ten (10) individuals for one (1) session.
2. Supplemental Administrator Training – three (3) hours for a maximum of ten (10) individuals for one (1) session.
3. Initial End User Training – eight (8) hours for a maximum of ten (10) individuals over two (2) sessions.
4. Supplemental End User Training – four (4) hours for a maximum of ten (10) individuals over two (2) sessions.
O. Initial training is conducted when the system is set up and constitutes the first training sessions for the operators. It is the intention of this session to be structured as recommended by the manufacturer to cover all software/hardware/and operational features for comprehensive training of the system.

P. Supplemental training is conducted after the operators have had time to work with their system and may have additional follow-up questions or additional materials they wish to cover. This will typically be conducted after the Initial training sessions and after 30 to 90 days of system operation or when requested by the Owner. It is the intention of this session to be an open exchange of information in a question-and-answer format based on the particulars of the operators. This training shall be coordinated with the Owner to coincide with a time that is acceptable to the Owner and the operators.

3.08 RECORD DRAWINGS AND DOCUMENTATION

A. At the conclusion of the work and prior to the commissioning of the system, prepare ALL:
   1. Record drawings
   2. Configuration documentation
   3. Board level system manuals, in accordance with the submittal requirements and submit these prior to the final commissioning walk through.

B. Provide an IDS system report showing all points reporting as alarm conditions and clearing as restorals.

C. The riser diagram shall accurately represent the true number of all major components. For example, the number of reader control panels fed from an intelligent system controller, and the number of portals serviced by reader control panel must be accurate.

D. At each panel, enclosure and equipment rack location, a copy of the configuration documents, board level manuals and record drawings shall be included for all equipment supported and installed at the panel and enclosure location. Each equipment rack shall have a full complement of system documentation. Drawings shall be large enough so that all device call outs and notes relative to the SMS are legible to the naked eye. Standardization of one size of drawing shall be carried throughout the SMS for this requirement. This documentation shall be housed in the print pocket as required in this specification.

E. Record Documentation Submission Formats:
   1. Submit to the Owner, one complete, color, PDF set of record drawings, system documentation, product data sheets and manuals.
   2. The cover sheet shall have titles appropriately documenting the following:
      a) Owner/Client
      b) Facility name and address
      c) Type of documentation
      d) Date of production
      e) Name of Contractor responsible for the system at the time of completion
   3. Data sheets and manuals shall be created as PDF files in color on 8 ½” x 11” paper.
   4. PDF Record Drawings shall be in 11” x 17” format.
   5. The following sections shall be created with sub-folders to delineate the following section types:
a) Operations Manuals  
b) Installation Manuals  
c) Maintenance Instructions  
d) Record Drawings  
e) Data Sheets  
f) Warranty Information  

6. The folder sections noted above shall, where applicable, be sub-sectioned by each individual device or component.  

F. Record Documentation Submission Types Required:  

1. Operations and Installation Manuals  
a. Final copies of each of the manufacturer's commercial manuals arranged as specified as PDF files. Final copies shall be doubled sided and in full color. The start of a new device's cut sheet shall not be on the back of any other page. The draft copy used during site testing shall be updated prior to final delivery of the manuals. Each manual's contents shall be identified on the cover.  
b. The manual shall include names, addresses, and telephone numbers of each Sub-Contractor installing equipment and systems, and nearest service representatives for each item of equipment for each system.  
c. The manuals shall have a table of contents and tab sheets. Tab sheets shall be placed at the beginning of each chapter or section and at the beginning of each appendix. The final copies delivered after completion of the performance verification test shall include all modifications made during installation, checkout, and acceptance.  

2. Operations Manuals  
a. Operation manuals shall contain all instructions required for operation of the system from the end user's perspective.  

3. Installation Manuals  
a. Installation manuals shall contain all information required for the installation of the device(s) as they pertain to the installation of this scope of work.  

4. Maintenance instructions and manuals  
a. Provide an instructional document detailing first line troubleshooting protocols for the Owner to identify potential problems and the threshold for making a service call to the integrator of record:  
(1) During business hours  
(2) After business hours  
b. The maintenance manuals shall describe maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.  
c. System maintenance information shall describe maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.
5. Record Drawings
   
a. ALL record drawings shall follow the same formatting and title block information requirements listed below.

b. All drawing device symbology shall utilize the SIA symbols as the base symbols. Slight modifications of the SIA symbols may be permitted with prior approval by the Owner’s representative.

c. Record drawings for inclusion in system enclosures may be printed in smaller formats to accommodate available space as long as all text is legible to the naked eye. In no case shall the printed format be smaller than “B” size.

d. The quantity and type of drawings shall be no fewer than the quantity and type provided with the bid package. If additional drawings are required to fulfill additional requirements of this specification, they shall also be provided.

e. Drawing grammar shall be brought current by removing words such as proposed, potential, preliminary, to be, etc. All wording shall be in a factual stated manner.

f. All revision clouds and revision deltas or other revision notations shall be removed from the drawings. The revision section of the title block shall indicate a “0” zero, with the description of “AS-BUILT” along with the date the set is updated for this requirement. There shall be no other revision notations in this section of the title block.

g. The drawing status shall be updated from FOR BID, FOR CONSTRUCTION etc. to RECORD DRAWINGS.

h. Drawings shall be created in AutoCAD® in a version that is no older than two releases from the most current released version. Drawings submitted for this requirement shall be submitted in both PDF and AutoCAD.dwg formats.

i. ALL drawings shall be provided in a landscape format with the same title block.

j. Provide a title sheet and legends that indicate device types and symbol abbreviations. The title sheet shall be provided as the front page of the Record Drawing package. This shall include the project title, Owner’s company name, Security Contractor’s company name, system designer’s company name, legends and notes as applicable. If an additional page for legends and notes is desired it may be on the second page of the Record Drawing package and the first page shall be the title sheet.

k. Provide complete floor plan drawings depicting every device installed new or existing and captured as they pertain to this scope. Floor plan drawings shall be no fewer than the number of floor plans submitted in the original bid submission.

l. Drawing sheet numbers shall be identical to the bid set of drawings. Where additional sheets are added in addition to what was provided in the bid set, the sheet numbers shall follow the same format and be incremented in a logical fashion.

m. Devices and callouts shall be black. Drawing backgrounds shall be gray scale so that the devices and callouts are more visually pronounced.

n. Device location callouts shall not cover room names or room numbers or other relevant text or building elements. Callouts shall be positioned in white space whenever possible.

o. Provide updated schedules including but not limited to location-by-location device schedules and termination schedules.
p. ALL devices requiring IP addresses shall have their IP and MAC address noted on the floor plans and riser diagrams next to the device, as well as within the device schedule.

q. Provide updated drawings, which illustrate final field conditions; these drawings shall incorporate all changes to the construction documents.

r. Wire and cable run drawings including cable paths throughout the facility, and identification numbers. Cable pathing drawings shall be a separate set of floor plans from those which show the security devices as required elsewhere in this specification.

s. Functional block diagrams for all subsystems. Schematic diagrams for all custom circuitry and interfaces to work not-in contract.

t. A complete one-line riser for each system/site correctly depicting all system devices and their interconnections, showing the specific wire for each. Device counts must be accurate and identified by either location in the site, or with respect to the device numbers established on the RFP documents. “Typicals” will not be allowed.

u. Wiring schematics.

v. Line drawings of the elevations and equipment layouts within enclosures and equipment racks for equipment and/or riser closets, which show the exact configuration and physical installation of related equipment, interface panels, power supplies, junction boxes and equipment cabinetry. Each location shall have its own elevation detail, no typicals will be allowed.

(1) Note: If pictures of the panel elevations are provided as part of this requirement, it shall not eliminate the requirement for line drawings of the elevations and panel layouts.

w. For each panel/enclosure location, provide board level wiring diagrams depicting board interconnections and individual devices connected to each board. Devices shall include but not be limited to card readers, door contacts of any type, REX devices of any type, locking devices of any type, control relays, glass break detectors, intercom release inputs etc. No typicals will be allowed.

x. Drawings to be provided by the Contractor shall be modified versions of the provided files. Recreations of the original drawings shall not be permitted, unless they truly and accurately represent the originals in all aspects.

y. All additions shall be on a separate layer, so as to preserve the integrity of the original drawing.

6. Additional Record Documents and Files

a. IT Security Guidelines for ongoing maintenance of network connected devices.

(1) This document shall explain how the Contractor intends to maintain the integrity of the IT security processes outlined within this document and implemented during the project setup and programming stages.

(2) The document shall make recommendations for updates as well as the frequency at which those updates should be performed.
(3) The document shall also outline any additional measures that would be relevant to IT security best practices not already covered within this document.

b. Data Sheets – Provide final color copies not previously provided of all equipment data sheets that have been installed under this contract. Marking and identification provisions applied at the time of bid shall apply here as well.

c. Warranty – Provide an updated matrix of the manufacturers’ warranty for all products proposed under this submission.

d. Lien release certification on the installed equipment.

e. A portable copy of the system database(s) configuration shall be made once all users are programmed and all doors, input and output device settings are complete as part of the record documentation in the Closeout submittal. The portable copy shall be written to a USB connected storage device and provided to the owner.

(1) The storage device shall have a printed label identifying the site name, contents and saved date. The purpose of the storage device shall be to allow the database to be efficiently restored if the SMS or VMS server were to fail.

(2) A copy of the system database(s) configuration shall also be uploaded to the project FTP site into the appropriate folder.

f. Service Level Agreement (SLA) – a one year SLA documenting the following:

(1) Procedures for the complete SMS and VMS tests.

g. Pictures – Provide digital pictures documenting the final installation.

(1) Provide pictures of interior and exterior panel elevation assemblies. One picture shall be taken with the doors closed and another with the doors open. When there is more than one panel location, pictures for each location shall be provided and identified as to which location they are documenting.

(2) Provide pictures of the equipment rack elevations where SMS and VMS equipment reside. Pictures shall be taken of the front and back of the enclosure with the doors open and doors closed.

7. All electronic versions of the documentation required in this section shall be provided as individual files by SMS software type, equipment type and individual part number. Drawings shall also be provided as individual files by sheet name. This requirement is to prevent users of the documentation from having to scroll through potentially hundreds of pages of documentation to find what they are looking for.

3.09 PROJECT CLOSE OUT

A. GENERAL

1. The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform all testing of the Systems.

a) During system demonstration, Contractor shall provide a set of two-way radios with sufficient range to allow two-way communications from any two points on the site.

b) Cell phones will be accepted as substitutes for two-way radios, provided that coverage is available in all parts of the spaces and buildings being tested.
2. The Contractor shall calibrate and test all equipment, verify signal/control cable operation, place the integrated system in service, and test the integrated system.

3. The closet out consists of the following activities:
   a) Commissioning
   b) Endurance Test
   c) Final Acceptance

B. COMMISSIONING – Refer to Appendix B – Commissioning Worksheets.

1. Commissioning shall consist of an on-site walkthrough and demonstration by the Contractor that the completed systems comply with the contract requirements. The Commissioning shall test 100% of installed devices UON.

2. The commissioning procedure will be witnessed by the Owner's Representatives. The commissioning procedure shall be conducted by the Contractor and shall consist of a detailed inspection and a physical accounting of each equipment item.
   a) An operational demonstration shall then be conducted in which the equipment shall function in the normal operational mode and shall operate completely error-free in terms of alarms, hardware and software performance.
   b) The operational demonstration shall be conducted with individuals from the Contractor’s firm as follows:
      (1) One individual shall be the individual responsible for programming the systems. This individual will monitor the SMS client workstation on-site, to verify that alarms and card read data is properly displayed on the client workstation.
      (2) The second individual shall be the Contractor’s Project Manager responsible for this scope of work. The project manager shall work with the Owner’s Representative to review all field devices and panel locations.
      (3) It is highly recommended that the lead technician / site foreman for the Contractor also be present. This will allow for small deficiencies to be remedied immediately and prevent delay of Final Acceptance.

3. Commissioning shall not be scheduled until all of the Record Documentation requirements have been met AND accepted by the Owner’s Representative.

4. Outstanding work items that may exist, such as facility interfaces, and/or in-process change orders, shall be documented and submitted to the Owner’s Representative for review prior to the start of Commissioning.

5. Documentation of outstanding work items shall take the form of punch lists of critical action items lists that describe the work, the expected completion schedule, and the impact upon operation.
   a) Depending upon the nature of the outstanding work items, the Owner may grant a waiver to accomplish partial Commissioning of any of the equipment. Completion of waived outstanding work items shall then be assigned to the post-commissioning operations and maintenance.

6. A portable copy, written to a USB connected storage device, of the system database configuration shall be made once all users are programmed and all doors, input and output device settings are complete as part of the record documentation.
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a) The USB storage device shall have a printed label identifying the site name, contents and saved date.

b) The purpose of the USB storage device shall be to allow the database to be efficiently restored if the SMS server were to fail.

7. Occurrence of any equipment failure may terminate the demonstration.

8. The demonstration shall restart and run for a period of time designated by the Owner's Representative after the failure has been corrected.

9. Except for any outstanding work items as previously described, this shall complete the Commissioning procedure.

10. Review of corrective action identified and compiled during the Commissioning process will follow the same rules and criteria of the section above.

11. The system will be considered successfully commissioned once all outstanding work and punch list items have been addressed and the deficiencies have been reviewed for commissioning compliance by the Owner's Representative or the Owner.

C. ENDURANCE TEST

1. After successful completion of the Commissioning and any outstanding punch list items resolved, the Systems endurance test shall be conducted 24 hours per day for seven consecutive calendar days, including holidays, and the system shall operate under normal conditions as specified.

   a) The Contractor shall make no repairs during this phase of testing unless authorized by the owner or system designer in the event of a major failure.

   b) If the system experiences no failures during testing, the Contractor may proceed directly to Acceptance Testing upon receipt of authorization from the architect.

   c) If the system experiences a major failure(s) during testing, the Endurance Test shall be stopped and rescheduled by the architect after the Contractor has completed necessary repairs and declares to the owner or system designer that the system ready for a second endurance test.

2. The Contractor will not be held responsible for failures in system performance resulting from the following:

   a) An outage of the main power more than the capability of any backup power source, provided that the automatic initiation of all backup sources was accomplished, and that automatic shutdown and restart of the Systems performed as specified.

   b) Failure of furnished communications circuit, provided that the failure was not due to Contractor furnished equipment, installation, or software.

   c) Failure of existing owned equipment, provided that the failure was not due to Contractor furnished equipment, installation, or software.

D. FINAL ACCEPTANCE

1. The system shall be ready for acceptance one (1) week prior to the system "on-line" date established by the Owner. The Contractor shall coordinate and obtain the date from the Owner.

2. The Contractor shall provide the following for system acceptance:

   a. All test reports and certification certificate.
b. Warranty matrix.
c. The punch-list cleared and completed and signed off from the Owner or architect.
d. Completed and approved Security Submittal Packages
e. Service level agreement for operation of the system, service calls, first line troubleshooting, maintenance and service.
f. Final Record drawings and documentation distributed to all panel locations.

END OF SECTION 28 10 00
SECTION 280011 – SELECTIVE REMOVALS, RELOCATIONS, AND REARRANGEMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. The Drawings indicate renovated areas and identify those portions of buildings where renovation work shall be provided. Identified areas of buildings show electronic safety and security work systems that shall be provided.

B. Removals, relocations and rearrangements shall be performed in all identified areas, as shown on Drawings.

C. The Contract Documents include D500 series Demolition Drawings. These Demolition Drawings shall be interpreted as incomplete, and in general represent existing building electrical conditions.

1. The Demolition Drawings included in the Contract Documents are not to be considered complete or accurate, and are included only to provide the general scope and extent of selective removals, relocations and rearrangements to be included.

2. Visit the site prior to submitting the bid, to verify existing building conditions, in order to more accurately establish the removals, relocations and rearrangements required.

D. The Demolition Drawings include description notes that provide an overall intent of removals, relocations, and rearrangements.

D. Examine the existing structures and installations for the work of other trades which will influence the cost of the work on this project. Include removals, relocations and rearrangements affecting the work of this Division as follows:

1. Relating directly or incidental to the construction.

2. The work of other Divisions which may interfere with, disturb, or complicate, the performance of the construction.

3. Involving systems and/or equipment and their relocated service lines which shall continue to be used or operated as part of the finished project.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 EXISTING CONDITIONS

A. Existing device locations have been identified as completely as possible by a site survey and by record documents as available. Be responsible for proper removal and rework of devices, equipment, and their associated work, not shown on Drawings to conform with intent of documents.

3.2 GENERAL RENOVATION REQUIREMENTS

A. Remove all electronic safety and security systems work presently installed on or in existing walls, ceilings and partitions which are to be demolished. Remove all exposed portions of wiring and raceways.

B. Where existing walls are to remain, remove all exposed raceways, exposed and concealed outlet boxes, etc., that are not to be reused. Where new raceways and outlet boxes are shown on existing walls in finished rooms, they shall be installed concealed by cutting and patching method.
C. Reuse existing outlet boxes and raceway systems wherever practical in renovation areas. Install new wiring devices, coverplates, and wiring per applicable specification sections, where such existing outlet boxes are used. Special coverplates may be required to suit conditions.

D. Disconnect and remove per NEC Articles 770 and 800, exposed Class 1, 2, and 3 remote control, power limited and non-power limited wiring and cables, and their associated raceways, including wiring and cables not installed in raceways rendered inoperable due to removals, relocations and rearrangements. This shall include the complete removal of wiring and cable, abandoned, above or below ceilings, by other Divisions as part of this project.

E. Disconnect, remove, rework, and otherwise rearrange existing raceways and wiring to accommodate new circuit arrangements indicated and/or required to maintain continuity of existing circuits feeding devices that are to remain.

F. Be responsible for removal and reinstallation of existing equipment, devices, components, etc., required to accommodate the work of, or disturbed by, other trades.

G. Do not remove or reuse existing electronic safety and security systems equipment, devices, components, etc., presently installed in project spaces being abated for asbestos. Equipment, devices, components, etc., installed in project spaces being abated for asbestos shall be considered hazardous material, and as such shall be removed as part of the asbestos abatement process.

H. Do not remove or reuse existing electronic safety and security systems equipment, devices, components, etc., installed in suspended, or other false ceiling spaces below known asbestos containing ceiling cavities. Equipment, devices, components, etc., installed in such ceiling spaces shall be considered hazardous material, and their removal shall be the responsibility of the Owner.

3.3 SALVAGING

A. Stockpile removed electronic safety and security system equipment, devices, on components, etc., and their associated wiring and cabling, on job site, for reuse, until project closeout unless specifically directed otherwise.

B. Legally remove items from site that the Owner does not wish to salvage.

3.4 SMOKE DETECTOR DISPOSAL

A. Remove existing ionization type smoke detectors (that the Owner does not wish to keep) from the project site, delivered to either a licensed and certified recycling provider, or to the original equipment manufacturer, for recycling and their disposal. Landfill disposal or construction waste disposal of ionization type smoke detectors is not permitted.

1. Dispose of photoelectric type smoke detectors as ordinary waste.

B. All costs associated with the recycling and disposal of smoke detectors shall be included in the work.

3.5 ABANDONED CABLE

A. Disconnect and remove existing wiring and cable, whether abandoned as part of this project, or existing abandoned, in their entirety.

END OF SECTION 280011
SECTION 280500 – COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general administrative, material, and procedural requirements for Division 28 installations to expand the requirements specified in Division 01.

1.2 REFERENCES

A. Abbreviations and Acronyms:

2. AHJ - Authority Having Jurisdiction.
4. AWG - American Wire Gauge.
5. BICSI - Building Industry Consulting Service International.
6. BDF - Building Distribution Facility; space within a building that is the nexus of LAN distribution for that particular building.
7. Broadband - Wide bandwidth equipment or systems that can carry signals occupying in the frequency range of 54 to 1002 MHz.
8. Cat – Category; based on numerical value of structured cabling performance.
9. CAT 3 - Category 3 performance as defined by ANSI/TIA/EIA-568-B.2.
10. CAT 5E - Category 5e performance as defined by ANSI/TIA/EIA-568-B.2.
11. CAT 6 - Category 6 performance as defined by ANSI/TIA/EIA-568-B.2-1.
12. CAT 6A - Augmented Category 6 performance as defined by ANSI/TIA/EIA 568-B.2-10.
13. CATV - Community Antenna Television.
14. CTS – Certified Technology Specialist.
15. DC - Data Center.
16. EIA - Electronics Industry Alliance.
17. ELFEXT - Equal Level Far End Cross Talk.
18. ER - Equipment Room.
19. EOR - Engineer of Record.
20. FOTP - Fiber Optic Test Procedure.
22. IR – Infra-Red.
23. ISP - Inside Plant cabling.
24. IT - Information Technology.
25. IDF - Intermediate Distribution Frame.
27. LOMMF - Laser Optimized Multimode Fiber.
28. LV - Low Voltage Room, Intermediate Distribution Facility; station and backbone cable concentration point on a particular floor for specific use on that same floor.
29. MCC – Main Cross Connect.
30. MDF - Main Distribution Frame.
31. MATV - Master Antenna Television.
32. Main Low Voltage Room - Main Distribution Facility; space within a building that is the main point of LAN distribution for that building or to other buildings.
33. MMF - Multimode Fiber.
34. MPOE - Main Point of Entry.
35. MHz – Megahertz.
36. NEXT - Near End Cross Talk.

COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY 280500 - 1

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37. NECA - National Electrical Contractors Association.
38. NEMA - National Electrical Manufacturers Association.
39. OSP - Outside Plant cabling.
40. OTDR - Optical Time Domain Reflectometer.
41. PSELFEXT - Power Sum Equal Level Far End Cross Talk.
42. PSNEXT - Power Sum Near End Cross Talk.
43. PTZ - Pan/Tilt/Zoom.
44. RCDD - Registered Communications Distribution Designer.
45. RF - Radio Frequency.
46. ScTP - Screened Twisted Pair.
47. SCS - Structured Cabling System.
49. STP - Shielded Twisted Pair.
52. Telecom Spaces - Include all areas where cable or equipment will be placed, including IT resources, engineering resources, and user stations.
53. TIA - Telecommunications Industry Association.
54. TBB - Telecommunications Bonding Backbone.
55. TSER - Telecommunications Service Entry Room.
56. TDR - Time Domain Reflectometer.
57. TGB - Telecommunications Ground Busbar.
58. TMGB - Telecommunications Main Ground Busbar.
59. TR - Telecommunications Room.
60. UTP - Unshielded Twisted Pair cabling.
61. UL - Underwriters Laboratory.
62. UNO - Unless Noted Otherwise.
63. UPS - Uninterruptible Power Supply.
64. WAP - Wireless Access Point.

B. Definitions:

1. In addition to those Definitions listed in Division 01, the following list of terms shall be defined as follows:

   a. Connect: To install required patch cords, equipment cords, cross-connect wire, etc. to complete an electrical or optical circuit.

   b. Cabling: A combination of cables, wire, cords, and connecting hardware e.g., cables, conductor terminations, connectors, outlets, patch panels, blocks, and labeling.

   c. Identifier: A unique code assigned to an element of the telecommunications infrastructure that links it to its corresponding record.

   d. Open Cabling: Cabling run horizontally within a pathway supported by cable tray, J-hooks, D-hooks, etc. that is installed above an accessible ceiling. This installed cabling is considered concealed.

   e. Exposed Cabling: Cabling that is not concealed by an accessible pathway, conduit, etc. Cabling installed open below an exposed structure.

   f. Concealed Cabling: Cabling rendered inaccessible by the structure or finish of the building.

   g. Pathway: Routing of cabling from work area outlet box to telecommunications room. Pathways may consist of conduit, conduit stub, conduit sleeve(s), cable tray, J-hooks, etc.
h. Telecommunications/Datacom Cabling: Low voltage extended frequency signal and communications cabling. Category 5e, 5E, 6, augmented 6 and fiber optic cabling.

i. System Cabling: Low voltage signal and control cabling. System cabling is designated by the manufacturer for a particular system in each specification section.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Substitutions:

1. The materials, products, and equipment described in the Bidding Documents establish a standard of required functions, dimensions, appearance, and quality to be met by any proposed substitution.

2. No substitution will be considered prior to receipt of Bids unless written request for approval has been received by the Architect/Engineer at least ten (10) days prior to the date for receipt of Bids. Each such request shall include the name of the material or equipment for which it is to be substituted and a complete description of the proposed substitute including drawings, cuts, performance, test data and warranties, and any other information necessary for an evaluation. A statement setting forth any changes in other materials, equipment, or other work for incorporation of the substitute shall be included. The burden of proof of the merit of the proposed substituted is upon the proposer. The Architect’s decision of approval or disapproval of a proposed substitution shall be final.

3. If the Architect approved any proposed substitution prior to receipt of Bids, such approval will be set forth in an Addendum. This Addendum shall then be issued to all Bidders.

4. Requests for Substitution shall be made only by a Bidder. Requests for Substitution received by the Architect from sales representatives, vendors, suppliers, etc., are not acceptable.

5. Refer to Division 01 for instructions on substitutions.

B. Permit and Inspections:

1. Permits: Obtain and pay for all permits, bonds, licenses, tap-in fees, etc., required by the City, State, or other Authority Having Jurisdiction over the work, as a part of the work of the affected sections.

2. Inspections: Arrange and pay for all inspections required by the above when they become due as part of the work of the sections affected. Conceal no work until approved by these governing authorities. Coordinate inspection period with the AHJ and Engineer through Construction Manager. Present the Engineer with properly signed certificate of final inspection.

C. Coordination:

1. Coordinate all programming components, device designations, and labels to match the final room numbers of the completed project. The room numbers on the Drawings may not be the final room numbers and may be finalized after system components are installed.

2. Coordinate arrangement, mounting, and support of Division 28 equipment:

   a. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.

   b. To provide for ease of disconnecting the equipment with minimum interference to other installations.

   c. To allow right of way for piping and conduit installed at required slope.

   d. So connecting raceways, cables, wireways, cable trays, and pathways will be clear of obstructions and of the working and access space of other equipment.

3. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
4. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
   a. Submit coordination drawings indicating proposed access door locations for review per Division 28 Section "Common Work Results for Electronic Safety and Security."
   b. Ensure access doors are sized to permit complete access for any concealed and/or inaccessible junction boxes, control and monitoring devices, elevator shaft and other items of equipment requiring access, maintenance, and/or operation.

   1) Assure access to devices per codes and local Authorities Having Jurisdiction.

5. Wiring and controls associated with equipment shall be furnished, installed, and wired in accordance with the manufacturer’s recommendations and applicable standards and codes. Provide installation instructions, locating dimensions and wiring diagrams for the other trades. Supervise the installation and start-up and test the equipment unless otherwise specified.

6. Equipment Furnished by Other Divisions: Equipment specified in other divisions and requiring communication and control connectivity shall be erected, aligned, leveled, and prepared for operation. Provide required controls and accessories along with installation instructions, diagrams, dimensions and supervision of installation and start-up. Provide the required terminations, accessories and programming furnished under the specifications for the other divisions. Install those controls and accessories not located in the provided equipment. Provide additional electrical controls, accessories, fittings and devices not specified under the equipment but required for a finished, operating job. Make final electrical connections. Participate in the start-up and test services.

1.4 SUBMITTAL PROCEDURES

A. General: Provide required submittals in accordance with Division 01 "Submittal Procedures."

B. Definitions:

1. Submittals: A written or graphical expression of the Contractor’s interpretation of requirements in the Contract Documents to show how the Contractor intends to fulfill those requirements and identifying deviations from contract.

2. Action Submittals: Required submittal which Engineer reviews and approves or takes other appropriate action to communicate to the Contractor the status if the submittal and subsequent action are required.

3. Other (Information, Closeout, and Maintenance and Material) Submittals: Required submittals which Engineer reviews and may elect to respond. If rejected by Engineer for not complying with requirements, resubmittal or other action may be required on the part of the Contractor.

4. Layout Drawings: Drawings assembled by the Contractor consisting of to-scale architectural floor plans with room numbers and elevations of the actual facility being constructed or renovated with equipment symbols utilized to represent the size, shape, and location of equipment.

5. Riser Drawings: By means of single lines and graphic symbols, drawings assembled by the Contractor depicting devices provided and their functions with connectivity to associated equipment. Locations shall be identified using room numbers.

C. Failure to Submit:

1. Contractor’s failure to provide submittals does not alleviate the responsibility to provide the requirements in the Contract Documents as interpreted by the Engineer. Correct non-compliant items.
D. Applicable Information:
   1. All information not applicable to the project shall be crossed out in the submittal. All applicable accessories, option, etc. shall be clearly indicated. Failure to comply shall be grounds for the submittal to be rejected.

1.5 ACTION SUBMITTALS
A. Submit action submittals in groups by specification number. For example, all structured cabling equipment identified within that section number, including cabling, components, faceplates and accessories shall be submitted simultaneously in one package.
   1. Equipment submitted from multiple sections under a single cover will not be reviewed.

B. Provide a complete submittal list with dates for submission of documentation to Engineer. Identify any submittals requiring priority processing and review based on equipment lead times or fast track construction. Ensure submittals that contain information that transcends section numbers are submitted simultaneously so that review is not delayed waiting for concurring information. Submit in hard copy and Microsoft Excel format.

C. Each system submittal shall contain the following minimum information in addition to the information requested in the individual section:
   1. Section number and equipment/device type in a bound submission.
   2. Table of Contents identifying equipment lists with numbered pages identifying equipment/device locations within submittal.
   4. Equipment/device quantities.
   5. Equipment/device product information sheets with submission designated, installation information, color/finish options, etc.
   6. Program information sheets.
   7. Coordination requirements with all trades.
   8. Program layout diagrams, riser diagrams, wiring diagrams, rack elevations, seismic requirements, etc. Utilize architectural, electrical, and communication symbology and room numbers to be consistent with Owner's standards.
   9. Training outline.
   10. Sample testing reports.
   11. Deviations from specifications, if any, highlighted with specific explanation and identification requiring Architect/Engineer specific approval.
   12. Identify any products that will no longer be available or will be discontinued by the manufacturer prior to the completion of the warranty period.
   13. Estimated equipment heat loads and power requirements. List and tabulate equipment specifically required in data rooms. Coordinate with Division 27 equipment as applicable.
   14. Submit qualifications based on quality assurance requirements.
   15. Provide secondary submittal for systems requiring programming and Owner input, review, and approval after programming meeting, sequence of operations review, etc. Provide all information in spreadsheet format in electronic and hardcopy.
   16. Manufacturer required information for base and extended warranties including submission requirements and timeframes.
   17. Provide copies of manufacturer's warranty information to Owner that is submitted directly to manufacturer.
   18. Identify any additional power requirements, communications connections or alterations needed to support the proposed equipment.
D. Submit the following action submittals as qualified in associated Division 28 Sections:
   1. Batteries and Battery Chargers (Submit with associated systems).

E. Action submittals submitted for other than those listed above or not specifically required in the appropriate Specification Section will not be reviewed or returned.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:
   1. Prepare coordination drawings in accordance with Division 01 Section "Project Management Coordination," to a scale of 1/4" = 1'-0" or larger; detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including, but not necessarily limited to, the following:
      a. Indicate the proposed locations of major raceway systems, equipment, and materials. Include the following:
         1) Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
         2) Wall and floor sleeve penetrations.
         3) Floor box and poke-through assembly installations.
         4) Equipment connections and support details.
         5) Sizes and location of required concrete pads and bases.
         6) Location of cable tray.
         7) LAN connections.
   2. Submit the following specific coordination drawings and others as defined in other Division 28 Sections:
      a. Head-end equipment.
      b. Equipment rack elevations.
      c. Security Rooms.
      d. Fire Command Center.
      e. Vestibules containing system devices.
   3. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
   4. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
   5. Coordination drawings do not omit the required submission of layout and plan drawings identified in other specification sections for review and approval.
   6. Contract Document drawing copies may be used as base for coordination drawings, then marked to depict actual equipment sizes and other requirements of coordination drawings. Those not marked will be rejected.
A. Operation and Maintenance Data:

1. Prepare and submit Operation and Maintenance manuals in accordance with Division 01 Section "Project Closeout." In addition to the requirements specified in Division 01, include specific Division 28 Section requirements, and the following information for equipment items:

   a. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
   b. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
   c. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
   d. Servicing instructions and lubrication charts and schedules, software release update and patch criteria.
   e. Individual characteristics for troubleshooting sequences for each item of each communications systems.

2. The minimum information that shall be furnished in the maintenance manual shall include the following:

   a. Title, table of contents, tabbed sections for each installed system in an organized 3-ring binder labeled with the project name and date.
   b. Emergency and warranty contact names and numbers for the contractor and vendor of each installed system.
   c. Final submittal copy with catalog cut sheets for every item for which a submittal was provided.
   d. Contract modifications and actual equipment and materials installed.
   e. Model numbers and serial numbers for all provided equipment.
   f. Provide a digital color photo (8-1/2 x 11 minimum) and .TIFF file on DVD-ROM of the following areas:
      1) All head-end equipment (racks) showing model numbers and final connectivity.
      2) All telecommunications equipment.
      3) All sound and video equipment racks and portable equipment.
      4) Interiors of manholes.
   g. On-hand spare parts list and complete parts list for each communication system.
   h. Manufacturers' recommended cleaning intervals and special procedures for each communications system device.
   i. Calibration and exercise procedures for each communications system device.
   j. Approved special construction details that differ from the details shown on Drawings.
   k. Testing and troubleshooting procedures unique to special systems. For example:
      1) Water tightness tests for manholes and handholes.
   l. Test reports; sign off and acceptance of manufacturer, vendor, etc.
   m. Inspection reports.
   n. Warranty information for all systems including individual manufacturer product warranties and system extended manufacturer warranty certificate where applicable.
o. Provide an additional engraved spare key for each system with documentation.
p. Required software programming information.
  1) Provide system programming design manual with Owner sign-off and associated meeting minutes.
  2) Provide software documentation and licensing information.
q. Training documentation and DVDs.

3. Drawings:
   a. Major cabling systems (trunk risers), size and location, for both interior and exterior; locations of control devices and distribution boxes.
   b. Major equipment locations (exposed and concealed), dimensioned from prominent building lines.
   c. In slab conduit routings.
   d. Outlet devices with final outlet nomenclature identified at each device.

1.8 MAINTENANCE MATERIAL SUBMITTALS
   A. Extra Material:
      1. Provide four (4) keys for every different piece of equipment which is equipped with a lock.
         a. Coordinate similar locks/keys for like equipment. Verify with Owner.
         b. Stamp keys with system name.
      2. Provide all other loose equipment specified/supplied for use with all systems.

1.9 QUALITY ASSURANCE
   A. General: Follow the procedures specified in Division 01 Section "Quality Requirements," Source Limitations.
   B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.
   C. Obtain similar products through one source from a single manufacturer.
   D. Manufacturers of equipment shall be firms regularly engaged in manufacturing factory fabricated systems and equipment whose products have been in satisfactory use in similar service for not less than three (3) years.
   E. All equipment shall be provided by an authorized dealer or distributor of the manufacturer to ensure authentic product and warranty will be provided. Provide all necessary documentation at time of delivery.
   F. Provide equipment as required by and/or listed in the specifications for a complete and operational system.

1.10 DELIVERY, STORAGE, AND HANDLING
   A. Comply with Division 01 Section "Product Requirements."
   B. Deliver products to the project site properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.
   C. Provide all documentation identifying authorized distribution of the products.

COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY
1.11 WARRANTY

A. All equipment, software, services, and programming shall be covered by a one (1) year parts and labor warranty from date of acceptance. Acceptance will be provided in writing by Engineer after system is installed, programmed, and tested to the satisfaction of the Owner.

B. All manufacturer product warranties shall be transferable to the Owner upon Substantial Completion of the project for the full term of the warranty.

C. All warranties shall be standard manufacturer agreements. "Special" project warranties are not acceptable.

D. For all existing systems being expanded or extended, provide an extension of the current maintenance agreement or warranty on all existing components of that system to ensure proper operation and maintenance of that equipment through the completion of the new warranty period.

PART 2 - PRODUCTS

2.1 REGULATORY REQUIREMENTS

A. Work and materials shall conform to and be executed, inspected and tested in accordance with the latest edition of the National Electric Code and with the governing rules and regulations of federal, state and local governmental agencies. References to "NEC" within the Division 28 Sections shall be considered synonymous to this electrical code.

B. Other codes and standards which will apply to this installation include the current editions of:

2. NFPA 70E – Standard for Electrical Safety Requirements for Employee Workspaces.

C. Where governing codes indicate the Drawings and Specifications do not comply with the minimum requirements of applicable codes, be responsible for either notifying the Architect in writing during the bidding period of the revisions required to meet code requirements, or providing an installation which will comply with the code requirements.

D. U.L. Listing:

1. All equipment shall bear the Underwriter's Laboratories (U.L.), or other approved agency, listing label. Acceptable alternates include:
   b. Wherein an item of equipment is specified to be U.L. listed, the entire assembly shall be listed by Underwriters Laboratories, Inc. Any modifications to suit the intent of the Specifications shall be performed in accordance with the National Electrical Code and listed by U.L.

2. Definitions:
   a. Listed: Equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation, that maintain periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets appropriate designated standards or has been tested and found suitable for use in a specified manner.
b. Labeled: Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicated compliance with appropriate standards or performance in a specified manner.

2.2 MATERIALS

A. Products and the terms materials, equipment, devices, components, assemblies and systems are considered synonymous.

B. All materials, unless otherwise specified, shall be new and be the standard products of the manufacturer. Seconds, rejects, or damaged materials will be rejected.

C. The equipment to be provided under these Specifications shall be essentially the standard commercial grade product of the manufacturer. Where two or more units of the same class of equipment are required, these units shall be products of a single manufacturer.

D. The listing of a manufacturer for certain equipment and systems does not indicate acceptance of a standard or catalogued item of equipment. All equipment and systems shall conform to the Specifications and the requirements listed.

E. All equipment and materials specified shall be products currently in production.
   1. If the specified item is not available or is discontinued, a similar product with the same features and functionality shall be provided from the same manufacturer in the newer/upgraded series of product.
      a. Provide information as to the anticipated availability of the provided products at the time of submission and installation. No products shall be provided that will be discontinued within the warranty period of the system.
   2. Equipment and/or devices discovered to be discontinued after submission approval will not be accepted and will require resubmittal for an approved replacement.

F. Product Selection for Restricted Space: Drawings indicated maximum dimensions for products including clearances between products and adjacent surfaces and other items. Comply with indicated maximum product dimensions.
   1. Assembly Selection: The Drawings indicate sizes, profiles, and dimensional requirements of assembly equipment. Equipment having equal performance characteristics and complying with indicated maximum dimensions and profiles may be considered, provided deviations do not change the design concept intended performance, or code/future extension provision clearances. The burden of proof of equality is on the proposer a minimum of 10 days prior to bid.

2.3 SOFTWARE PROTECTION

A. All software supplied with new equipment shall be warranted against leap year program disruption or failure. Refer to Division 01 Section "Warranties and Supplementary Conditions for Requirements."

B. All software supplied with new equipment shall be warranted against Daylight Savings Time program disruption or failure. Refer to Division 01 Section "Warranties and Supplementary Conditions for Requirements."
C. All software shall be the most current release of the latest available software of the equipment provided.
   1. BETA software versions will not be accepted.

2.4 LABELS
   A. Per Division 26 Section "Electrical Identification."

PART 3 - EXECUTION

3.1 EXAMINATION OF FIELD CONDITIONS
   A. Verification of Conditions:
      1. Examine areas and conditions under which work is to be performed. Verify that site conditions are satisfactory for installation of cable and components.
      2. Ensure components and conditions are in compliance with manufacturer's requirements, installation tolerances, and other conditions affecting performance.
   B. Pre-Installation Testing:
      1. Identify conditions detrimental to proper or timely completion.
   C. Evaluation and Assessment:
      1. Correct unsatisfactory conditions.
      2. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION
   A. General:
      1. Review device locations, telecommunication room locations, routings, trunk risers, pathways, details, and special features.
      2. Meet with the Owner's telecommunications representatives prior to each of the following installation tasks:
         a. Mounting cabinets and equipment grounds.
         b. Telecommunications room raceway installations.
         c. Pulling cable.
         d. Terminating cable.
         e. Labeling of cable and equipment.
         f. Testing cable.
         g. As-built documentation completion.
   B. Installation Guidelines:
      1. Install systems and components in accordance with equipment manufacturer's written instructions, in compliance with National Electrical Code, and with recognized industry practices, to ensure that each system complies with requirements and serves intended purposes.
      2. Comply with ANSI/NECA 1, Standard for Good Workmanship in Electrical Contracting.
C. Protection of In-Place Conditions:
   1. Handle components to be re-used carefully to avoid breakage, dents, scoring finishes, and impacts.
   2. Take precautions to protect any surfaces already in-place before continuing with work.
   3. Protect everything in existing space from dust and debris in an acceptable manner.
   4. Notify Engineer, in writing, of any damage to surrounding areas or surfaces already in place.
   5. Keep hands clean when handling ceiling tiles to avoid fingerprints and smudges on the finished installation. Use clean cotton gloves for maximum protection. Ceiling tiles should be handled carefully to protect the face and edges of the tile from damage.
   6. Old ceiling tiles can remain in the grid system by being moved to one side and then replaced. Avoid scratching or jamming the tiles.
   7. Support all existing cabling that is not supported above the ceiling.

D. Rough-In Preparations:
   1. General:
      a. Verify final locations for rough-ins with field measurements and with the requirements and dimensions of the actual equipment to be installed and connected.
      b. The Architect shall control the placement of wall and ceiling mounted communications systems devices and outlets. The intent is to aesthetically locate equipment/outlets by providing rough-in hardware, boxes and/or mounting plates, as required, when stud or furring may not be readily available for direct mounting. When drawing details or elevations are not available, consult with Architect’s representative for actual placement.
      c. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
      d. Refer to equipment specifications in Divisions 02 through 28 for rough-in requirements.
   2. Equipment:
      a. Install to facilitate service, maintenance, and repair or replacement of components of equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
      b. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
   3. Raceways and Cabling:
      a. Coordinate with system maximum cable lengths and address Engineer with conflicts.
      b. Arrange for chases, slots, and openings in other building components during progress of construction to allow for communications systems installations.
      c. Coordinate cabling installation requirements with installation of all pathways, raceways, outlet boxes, etc. as listed in Division 26 Section "Conduit Rough-In Systems."
      d. Right of Way: Give to piping systems installed at a required slope.

E. Protection of Equipment:
   1. Protect all equipment and materials from the elements, dirt and other damage from the time it is removed from the point of storage until final acceptance.
F. Installation Auxiliary Equipment:
   1. Provide all scaffolding, rigging, hoisting, and services necessary for erection and delivery of equipment and apparatus furnished into the premises. These items shall be removed from the premises when no longer required.

3.3 INSTALLATION

A. Interface with Other Work:
   1. Sequence, coordinate, and integrate installations of communications materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
   2. Coordinate communications systems, equipment, and materials installation with other building components. Be responsible for any changes in openings and locations necessitated by the equipment installed.
   3. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.

B. Systems Integration:
   1. Sequence, coordinate, and integrate the various elements of electrical, communications and telecommunications, systems, materials, and equipment.

C. General:
   1. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.
   2. When several devices are wall mounted in the same area, care shall be taken to align them horizontally and vertically.
   3. When field cutting hangers or supports with corrosion protection, apply approved sealant to restore corrosion protection.
   4. Install systems, materials, and equipment giving right of way priority to systems required to be installed at a specified slope.
   5. All screws, bolts, nuts, clamps, fittings, or other fastening devices shall be tightened in accordance with manufacturer instructions.
   6. Plaster debris and residue shall be thoroughly cleaned and vacuumed from boxes before cables are terminated.

D. Equipment:
   1. Install communications systems equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
   2. Match room numbers for labels, programming, etc. with existing/final room numbers approved by the Owner’s representative upon completion of this project. The room numbers on the Drawings are not necessarily the actual room numbers.
   3. Provide cabinets and associated raceway/pathway installations including special wire management auxiliaries.
   4. Provide all support devices to mount supplied and installed equipment at the appropriate device height. Conceal furring as required.
   5. Install equipment properly to avoid causing mechanical stresses, twisting or misalignment of equipment being exerted by clamps, supports, and cabling.
6. Coordinate branch circuit power connection to equipment as required to support the system being installed. Indicate additional power requirements on wiring diagrams at submittal stage for approval by Engineer.

7. Remove all dirt, dust, and construction debris from all system equipment. Touch-up scratched and marred surfaces to match original finishes to the satisfaction of the Owner and Engineer.

E. Raceways and Cabling:

1. Routing:
   a. Pull all cabling to rack or equipment backboard in telecommunications room from outlet boxes shown on Drawings.
   b. Conceal all cabling in the facility except where specifically indicated otherwise. Surface raceway allowed only where specifically shown on Drawings or approved by Engineer.
   c. Install horizontal cabling open in accessible ceiling spaces. Install each cabling system in separate pathway from other cabling systems.
   d. Install all cabling parallel and perpendicular to building lines.
   e. Install cabling tight to building steel. Avoid locating cabling within 12 inches of lay-in ceilings or access panels.
   f. Traverse common system cables along the same pathway. Multiple runs of cabling terminated at roughly the same geographic area shall traverse the same path whenever possible.
   g. Verify all conduits are reamed and bushed prior to pulling cable. Do not pull cable if field manufactured bends reduce the recommended bending radius.
   h. Route cabling to avoid elevator shafts, elevator equipment rooms or any areas that contain or store hazardous materials.
   i. Avoid sources of electromagnetic interface (EMI) for all voice/data/system equipment and cables.
      1) Maintain 5 inch minimum from lighting ballast.
      2) Maintain 4 foot minimum from all transformers.
      3) Maintain 1 foot minimum from electric power conductors.
      4) Distances may be reduced if sufficient EMI isolation is provided and prior approval is given by the Engineer.
   j. Avoid routing cabling in areas subject to excessive environmental conditions.
      1) Refer to Division 26 Section "Conduit Rough-In Systems" for environmental requirements.

2. Supports:
   a. Coordinate cabling installation such that it is not supported from new or existing conduits, piping, ductwork, etc. Cabling shall not lie directly on ceiling or be supported by ceiling tie-wires.
   b. Support vertically routed cabling at each floor. Attach supports such as wire mesh grips as recommended by manufacturer and required by local codes.
   c. Do not support cables by their terminals.

3. Damage Prevention:
   a. Provide caution during installation so as to not stress or provide excessive tension on the cable.
      1) Pulling tension shall not exceed 25 lbs. on a single cable or bundle.
2) Avoid unnecessary bends and do not exceed a 90 degree bend for any cable.
3) Do not exceed manufactures bend radius requirements.

b. Replace entirely any cable jacket that is cut or scored.
c. Do not employ pulling lubricants as they can degrade cable performance.

4. Terminations:
   a. Terminate all horizontal and backbone cabling at each cable end as indicated.
   b. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B, and the National Electrical Code.

3.4 PAINTING

A. Provide the prime painting of all equipment and materials furnished under Division 27 Specifications, unless specifically stated otherwise. In general, all equipment except raceways and galvanized boxes that are not provided with a factory-applied final finish shall be delivered to the job site with a shop-applied prime coat of paint. Refer to Division 09 Sections "Interior Painting" and "Exterior Painting."

1. Provide touch-up painting services for any equipment as required and approved by the Engineer.
2. Replace any damaged equipment that cannot be returned to a "Like New" condition/finish.

3.5 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 01 Section "Cutting and Patching." In addition to the requirements specified in Division 01, the following requirements apply:

1. Perform cutting, fitting, and patching of equipment and materials required to:
   a. Uncover Work to provide for installation of ill-timed Work.
   b. Remove and replace defective Work.
   c. Remove and replace Work not conforming to requirements of the Contract Documents.
   d. Remove samples of installed Work as specified for testing.
   e. Install equipment and materials in existing structures.
   f. Upon written instructions from the Architect, uncover and restore Work to provide for Architect observation of concealed Work.

2. Cut, remove, and legally dispose of selected equipment, components, and materials as indicated, including but not limited to, removal of electrical items indicated to be removed and items made obsolete by the new Work.
3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
5. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
6. Painting:
   a. Refer to Division 01 Section "Definitions and Standards" for definition of experienced "Installer."
b. Provide paint note to renovation projects where painting is covered by Division 01.
c. Paint to match existing surfaces if painting is not provided by Division 01 or as indicated.
d. Refer to Division 01 Section "Definitions and Standards" for definition of experienced "Installer."

3.6 LABELING

A. Labels shall be applied by the installer at a visible location on all end-user device faceplates per Owner requirements and verbiage shall clearly identify device, use, destination, and location per Division 26 Section "Electrical Identification."
   1. Provide engraved faceplates for devices without a designated label location or means of protecting/securing the label.
   2. Standard manufacturer device plates shall provide engraved supplementary information as noted above.

B. Engrave label all keys provided to the Owner for system cabinets and devices.
   1. Label with system name as required by the Owner.

3.7 PROGRAMMING DESIGN MEETINGS AND MANUAL

A. Meet with Owner’s representative to develop a system programming design to function for the operations needed. Document all meetings for review by the Engineer.

B. Provide sample programming requirements, system features, etc. for review by Owner and coordinate correspondence with other facility representatives that have installed similar systems.

C. Provide a customized Programming Manual identifying the project name, job number, and date of installation.
   1. Provide all documentation in spreadsheet format on CD-ROM and hardcopy.
   2. Provide features utilized and identification.
   3. Identify features available per the Specifications and the product not required based on Owner requirements.
      a. Features not identified to the Owner as available and not listed may be required by Owner after initial use and operation of the system is found to be inadequate without such features. It will be required to have the necessary features installed and programmed for use at no additional cost to the Owner.
   4. Provide alterations/configurations based on time of day, day of week, holiday, etc.

3.8 LICENSES

A. Provide the necessary licenses for all devices and equipment to operate for the life of the product.
   1. Equipment/devices shall not require licenses to operate with the current or any updated/upgraded software release or version.

3.9 FIELD QUALITY CONTROL

A. Do not cover up or hide from view any communications systems equipment before it has been examined and approved. Any unsatisfactory work or materials shall be removed and corrected immediately.
B. Tests and Inspections:
   1. Submit a detailed test plan for all equipment and cabling prior to start of testing. Test plan shall provide for Engineer to witness test.
      a. The following will be witnessed by the Engineer:
         1) As-Built Drawings will be verified with actual installation.
         2) Workmanship of installation of equipment.
         3) All systems are fully programmed and functional, including interconnections with other systems.
      b. Any electrical equipment in vicinity of cabling or devices shall be on and operational during testing, including luminaires, elevators, HVAC units, and wireless devices.

C. Manufacturer's Services:
   1. Where supervision by a manufacturer is specified, follow all instructions, recommended manufacturer and specified field tests, and other recommendations of the manufacturer. The manufacturer shall supervise the installation, connection, start-up, testing, adjustment, instruction of the Owner, and final tests of such equipment or system. Where two or more manufacturer's equipment are interrelated, take responsibility to coordinate their work and provide supervision.

3.10 ADJUSTING
A. Complete all system programming to the satisfaction of the Owner. If after preliminary use of the system or training, the increased understanding of the systems features and capabilities necessitate programming or set-up adjustments, perform these programming updates at no additional cost.
B. Provide software programming changes to match Owner's final room number designations. The room numbers shown on the Drawings are not necessarily the final room numbers and may be subject to change by the Owner.
C. Provide on-site assistance in reprogramming software based system to suit actual occupied conditions during the warranty period. Provide up to three (3) 8 hour visits to the site for this purpose.

3.11 CLOSEOUT ACTIVITIES
A. Upon completion of the work, notify the Architect in writing that each entire system installation has been examined, inspected, tested, calibrated, or adjusted as specified and that it is ready for final inspection. Work to be connected prior to final inspection and also to include all of the work specified for "Manufacturers Services." Include documentation of specified testing and inspection.
B. Training:
   1. Have the manufacturer instruct the Owner in the proper operation and maintenance techniques of all equipment, systems, etc., at the time of completion of all work.
   2. Provide a training outline for distribution to the Owner for all required training and the necessary personnel required for operation, maintenance, and service (warranty) notification. Include instructors' qualifications.
      a. Training shall be provided in session increments of at maximum eight (8) hours. Minimum of two (2) hours.
      b. Coordinate all training to best service participants based on job description.
c. Provide several sessions as required to meet participants' schedules, etc. Coordinate dates and times with Owner's representative three (3) months prior to start of training.
d. Training shall be completed at the Owner's facility and all necessary devices, equipment, and training aids shall be provided. Training aids shall include approved maintenance manual.
e. Provide a refresher training session of at minimum two (2) hours 30 days after original training has been completed.

3. Provide PowerPoint presentation and handouts for all training. Class sizes shall be appropriate for the system to allow hands-on instruction.

4. Record each training session and provide an edited DVD of each training session to be turned over to the Owner.

5. Off-Site Training:
a. If required by the Specification section, provide factory training for designated Owner personnel at the manufacturer's training facility.
b. Include all associated costs including transportation, lodging, meals, etc.

C. Software Turnover:

1. All software for system operation including source code for proper operation, reconfiguring, and/or reworking of systems in future implementations shall be provided to the Owner by the manufacturer and/or vendor for the Owner's future use.
a. This shall include any license agreements, associated costs, and fees for turnover of this information.
b. The provided programming and source code shall become the intellectual property of the Owner.
c. Supply on CD-ROM and format required by equipment for re-installation and re-programming.

END OF SECTION 280500
SECTION 281300 – ACCESS CONTROL/INTRUSION DETECTION SYSTEM

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Provide a complete installation of the Genetec Access Control/Door Monitoring/Motion Detection/Identity Management/Security System throughout the facility. This requires seamless operation with all specified buildings located on the campus via the Wide Area Network.

B. Requirements of the following Sections apply to this Section:

1. Division 08 Section "Door Hardware."
2. Division 26 Section "Common Work Results for Electrical."
3. Division 26 Section "Raceways."
4. Division 26 Section "Conduit Rough-In Systems."
5. Division 28 Section "Closed Circuit Television Systems."
6. Division 28 Section "Video Surveillance Systems."

1.2 WORK INCLUDES

A. The work includes furnishing all labor, materials, tools, and equipment, and documentation required for a complete and working Access Control System (ACS) as specified in this Section. This scope of work shall cover the requirements for the access control, alarm monitoring (door contacts and motion detectors) and badging system.

1. Integrate with CCTV/Video Surveillance Equipment directly into the desktop software interface as indicated in these Specifications.

B. The ACS specified herein shall be fully compatible and coordinated in seamless operation with the purchased equipment for existing Campus Buildings.

C. All equipment shall operate and function as a single system with existing campus buildings via Owner WAN connectivity for updating user profiles, access rights and recording events. Multiple system data entry steps will not be acceptable to perform events/functions at other buildings.

1. Example, adding a user card at the Library will update system at this facility automatically.

1.3 REFERENCES

A. Design and operation of the system shall conform to the following referenced codes, regulations, and standards as applicable:

2. UL 294 and UL 1076 as required where applicable.
   a. The system shall be listed by Underwriters Laboratories for UL 294 Access Control Systems, and UL 1076 Proprietary Burglar Alarm systems. Bidders shall provide copies of their UL listing cards or other proof of compliance.
3. FCC Rules and Regulations:
4. National Electrical Manufacturers Association (NEMA):
   a. Section 250 Enclosures for Electrical Equipment.
5. Applicable Federal, State, and Local laws, regulations, and codes.
6. CE mark as and where applicable.

1.4 GENERAL PROJECT DESCRIPTION

A. The Access Control System (ACSACS) shall be capable of integrating multiple building functions including access control, alarm management (paging), intrusion detection, video imaging and badging, database partitioning, and external system database sharing of employee personal information (MIS interface).
   1. Operate in conjunction with Owner-provided ODBC software to integrate reporting features.

B. The ACSACS shall interface with the Building Automation System. Provide alarm coordination of BAS system equipment through Security System as required.

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of network controllers, card readers, and sensors.

D. The system shall incorporate the necessary hardware, software, and firmware to collect, transmit, and process alarm, tamper and trouble conditions, access requests, and advisories in accordance with the security procedures of the facility. The system shall control the flow of authorized personnel traffic through the secured areas of the facility.
   1. System shall be able to process other system alarms and distribute notifications via e-mail, phone, and pager as directed by specific alarm procedures.
      a. System shall be capable of processing alarm requests from other systems as identified and implement specific procedures for identifying and resolving alarms and requests.
         1) CCTV System.
         2) BAS System.
         3) Emergency Generator.
         4) Defibrillator Actuation.
         5) Telephone System/Emergency Phones.
            a) Duress Processing.

E. The system control at the control computer location shall be under a single software program control, shall provide full integration of all components, and shall be alterable at any time; depending on facility requirements. System shall be capable of reconfiguration through online system programming, without hardware alterations.

F. The software program shall be a true 64-bit, 3-tier client/server, ODBC compliant application based on Microsoft tools and standards. The system shall be able to share or retrieve information from other AMU databases. It shall be capable of analyzing other databases and flagging discrepancies in either database. Provide notification of discrepancies upon completion
   1. The software program shall consist of multiple servers including, but not limited to, Database Server, Communications Server, The Servers shall be capable of being installed on one or more PCs across a network providing a distribution of system activities and processes.
   2. The data architecture shall be compatible with the existing database.
   3. The system software shall be accessible via Web browser based for standard tasks such as monitoring, altering privileges, IT shall support multiple accounts allowing separate simultaneous access to the card database, badge layout, operator access, and reporting. Access levels and time zones shall be global to allow for easy administration.
4. Multi-user multitasking to allow for independent activities and monitoring to occur simultaneously at different workstations.
5. Graphical user interface to show pull-down menus and a menu tree format that complies with interface guidelines of Microsoft Windows operating system.
6. System license shall be for the entire system and shall include capability for future additions that are within the indicated system size limits specified in this Section.
7. System shall have open architecture that allows importing and exporting of data and interfacing with other systems that are compatible with Microsoft Windows operating system.
8. Password-protected operator login and access.

G. Network connecting the Security management system, controllers and workstations shall be LAN based using Microsoft Windows-based TCP/IP.

H. Network(s) connecting PCs and Controllers shall consist of the following:
   1. Local area, IEEE 802.3 Fast Ethernet star topology network based on TCP/IP.

I. The system shall support both manual and automatic responses to alarms entering the system. Each alarm shall be capable of initiating a number of different actions, such as camera switching, alarm initiation/notification, video pop-up, activation of remote devices, door control, and activation of WAV files.
   1. The system shall provide both supervised and non-supervised alarm point monitoring. Upon recognition of an alarm, the system shall be capable of switching and displaying a view from either the CCTV camera or video from the digital video server camera that is associated with the alarm point. The system shall be capable of arming or disarming alarm points both manually and automatically, by time of day, and by day of week.

J. Access control functions shall include validation based on time of day, day of week, holiday scheduling, site code and card number verification, automatic or manual retrieval of cardholder photographs, and access validation based on positive verification of card, card and PIN, card or pin, pin only, and Site code only.

K. CCTV Integration:
   1. Camera functions such as pan/tilt, lens control, limits, and home position shall be supported by the system. Unless specific programming dictates otherwise, an operator shall be able to control these functions for all cameras so equipped.
   2. Live video from a CCTV system and/or digital video server shall be able to be displayed on the computer screen. The live video window shall allow the user to change its size and location on the computer screen. Video controls (pan, zoom, camera/monitor selection) shall be able to be sent to the CCTV system and/or digital video server from the live video window. The user shall have the ability to freeze and save a single frame of video from the CCTV system to a file.

L. Notification:
   1. Alarm events with defined priorities shall be able to pop-up automatically in an alarm event window for operator attention. The pop-up shall display the name of the event (reader, alarm point, cardholder or system alarm), time, date, site, account, if a card event, the card number, type of event and cardholder name. An event counter shall also display the number of times the event was reported to the Alarm event monitor prior to Acknowledgement or Clearing the event. Event instructions shall be made available by double clicking on the event. The event shall also display an icon to indicate that video is available for events so programmed.
2. The Alarm event window shall allow the operator to initiate a physical response to the event as well as a written response. Responses shall include, but not be limited to, acknowledge, clear, open a pre-programmed floor pan, energize, de-energize, pulse, time pulse, add comment, retrieve event video, and bring up live video, shunt or un-shunt.

M. Password Operation:
1. Assigned passwords shall be possible to define the levels of system operation for each individual operator. System operation for individual operators shall include, but not be limited to, restricted time periods for login, available accounts and default language selection at login. Operator actions range from no view or control rights to basic monitoring including the ability to block the viewing of card and or personal identification numbers, to full control of the system including programming.

1.5 SUBMITTALS
A. General: Submit the following in accordance with Division 28 Section "Common Work Results for Electronic Safety and Security."

1.6 SUBMITTALS
A. General:
1. Submit the following in accordance with Conditions of Contract, Division 01 Specification Sections.

B. Submittals shall be provided based on specification number and be inclusive of the equipment within that section. Equipment submitted from multiple sections under a single cover, will not be reviewed.

1.7 ACTION SUBMITTALS
A. Product Data: Submit for each type of product specified.
1. Provide manufacturer's literature to include all information necessary to confirm that the proposed system is in complete compliance with the Specifications.
2. Provide all information in a single, complete bound submission.
3. Table of Contents identifying equipment lists with numbered pages corresponding to equipment/device locations within submittal for quick reference.
4. System Scope of Work narrative including Sequence of Operation of all devices and system functionality, Owner meetings, Owner reviews, programming approval, milestones, and testing.
5. Equipment Information:
   a. All equipment shall be specific to this section only unless required for integration.
      1) Manufacturer’s specifications and descriptive literature.
      2) Manufacturer’s recommended installation procedures.
      3) Equipment/device quantities.
      4) Equipment/device product information sheets with submission designated, installation information, color/finish options, etc.
      5) Program information sheets.
      6) Coordination requirements with all trades.
      7) Program layout diagrams, riser diagrams, wiring diagrams, rack elevations, seismic requirements, etc. Utilize Architectural, Electrical, and Communication symbology to be consistent with Owner's standards.
1) Provide Facility location and name.
2) Owner’s or User’s name, address, and telephone (including fax) numbers.
3) Date of Project Start and Date of Final Acceptance by Owner.
4) System Project Number.
5) Brief (three paragraphs minimum) description of each system’s function, operation, and installation.

c. Provide certification with data substantiating that products comply with requirements of the Contract Documents. Furnish UL File number with product data as submitted.

B. Shop Drawings (Submit for each):

1. Layout Drawings:
   a. Submit scaled system layout drawings using architectural floor plans indicating head end equipment layout and dimensions. Include layout of equipment in relation to room size and other existing and new system equipment in that room. Include equipment layout and rack elevations.
      1) Indicate connections to equipment supplied by others.
   b. Submit scaled system layout drawings using architectural floor plans for system equipment indicating cable types, cable quantities amplifiers, electrical connections, taps, etc., as designed for this project.
      1) Show device locations that correspond to the floor plans. Identify camera type and associated coverage of camera on the floor plan for review and coordination with owner.
      2) Include lengths of all horizontal cables and cable type.
      3) Provide building room numbers and diagrams specific to this project.
      4) All panels, plates and designation strips, including details relating to terminology, engraving, finish and color.
      5) Detailed wiring for connectivity of other interfaces. Differentiate clearly intersystem connections.
6) Wiring Diagrams detailing wiring for power, signal, and control differentiating clearly between manufacturer-installed wiring and field-installed wiring. Identify terminal numbers and wiring color codes to facilitate installation, operation, and maintenance.

7) Remote control panel design (to include "live" interactive electronic format).

8) All equipment racks, cabinets, consoles, tables, carts, support bases and shelves.

9) All non-factory equipment modifications.

10) Front mechanical drawings of each equipment rack.

11) System functional block drawings, including those for audio and video subsystems.

12) Cable labeling plan.

13) Grounding: Identify grounding requirements and connections to Telecommunications Grounding Busbar.

14) Differentiate between portions of equipment that are factory/vendor assembled and that which are field-installed.

C. Coordination Drawings (1):

1. Details of system including but not limited to the following:
   a. Console layouts.
   b. Control panels.
   c. Rack arrangements.
   d. Interface method to other systems or equipment.

Integration: Detail interconnections to other systems.

1.8 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. Provide documentation verifying requirements identified in Quality Assurance Section.

2. Supplier Qualifications:
   a. Certification signed by officer of installation company attesting that proposed system complies with specification requirements:
      1) For multiple firms, an officer from each firm must sign.
   b. The Contractor shall be a licensed security Contractor as required within the state and jurisdiction of where the installation work is being conducted. For AHJ requirement:
      1) Copy of jurisdiction electrical license or permit.

3. Installer Qualifications:
   a. Provide documentation of certification of manufacturer, supplier, installers, project managers and instructors to be utilized on this project. Documentation to include the following:
      1) Manufacturer Training and Certifications:
a) Submit contractual relationship or technical certification by the respective equipment manufacturers that installer is authorized by that equipment manufacturer to pass through the manufacturer’s certification and equipment warranty to the Owner. Additionally, the equipment manufacturer and Contractor shall accept complete responsibility for the design, installation, certification, operation and physical support for the system.

b) Have a minimum of 5 manufacturer certified technicians on all products provided for this project. The technicians shall have a minimum of five (5) continuous years of technical experience in video surveillance and electronic security systems.

b. Project Manager Resume'.

4. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation within 24 hours of receipt of notification that service is needed. Submit name and address of service organizations.

5. Manufacturer’s Instructions:
   a. Manufacturer’s recommendations for installing.
   b. Provide documentation of certification of manufacturer, supplier, installers and instructors to be utilized on this project.

B. Coordination Data:
   1. Coordination Drawings:
      a. Provide trade coordination drawings of corridor ceilings with limited space where congestion with other systems may be a problem.

1.9 CLOSEOUT SUBMITTALS

A. Operations and Maintenance Data:
   1. Final Submittal Copy:
      a. Approved copy of system submittal.
      b. Provide a listing of individual product/device/equipment warranties provided from the manufacturer with expiration dates identified.
      c. Provide a complete listing of devices, installed locations with product serial numbers for product tracking.
      d. Provide all equipment and device licensing information equal to the lifetime of the product with the current system integration.
      e. Provide a complete set of equipment cut sheets, parts list, including maintenance criteria, “troubleshooting” guide, distributor information and service information for all equipment provided.
      f. Provide a complete set of instruction manuals; including complete written programming instructions, programming documentation and system set-up documentation.
      1) Provide an additional quick-start guide with all commonly used procedures for operating the system. Laminate and provide copies during training session.
      g. Provide all test results performed. Include manufacturer's certifications that installed system complies with specification requirements.
2. Special Warranty Information:
   a. Provide copy of all documentation including test results sent to manufacturer for system warranty.
   b. Provide all required documentation to the system manufacturer to initiate and ascertain the warranty specified.
   c. Provide warranty of the system by the system manufacturer and guaranteed for the term of the warranty.

3. Service Contract:
   a. Provide copy of first service contract terms for Owner evaluation prior to accepting or rejecting service contract.

B. Record Documents:
1. Operation and Maintenance Data:
   a. Include the following in emergency, operation and maintenance manuals.
      1) Three (3) final corrected copies of catalog data and shop drawings, critical spare parts list, and manufacturer's operation and maintenance data applicable for the equipment furnished.
      2) Instructions for periodic testing.
      3) Warranty information.

2. Record Drawings:
   a. Record drawing indicating locations of all system components.
   b. Provide a revised set of system wiring diagrams upon the completion of the installation for subsequent testing of the system to show actual cable routing, connections with other systems, cable lengths values of all equipment as installed and actual signal values as tested.
   c. Utilize architectural floor plans for system layout.

3. Training / Demonstration Video.
5. Manufacturer software CD for products provide as part of the system.
6. Provide electronic copy of system programming and configuration at time of Owner signoff. This is to include but not limited camera configurations, VMS software configuration systems for use in disaster recovery of the system.
7. Final Field Quality Control Test Reports. Document items identified in the testing section.

1.10 OPERATIONAL REQUIREMENTS

A. Scope of Work for this Project:
2. Communication between ACS workstation, network controllers and workstations shall be over the hospital Ethernet network.
3. All motion detectors shall be wired to new Card Access/Building Security network controller.
4. Provide door contacts at all building door entrances and overhead doors as shown on the Drawings and connect to building security system controllers.
5. The following functions shall be provided via web access to process navigation, data visualization and object attribute interaction, and graphic floor plans. Provide via this interface access for alarm management for viewing and acknowledging all pending critical ACS conditions including archived message analysis, which is provided by the alarm management program.

B. Functional Description of System:

1. Central-Station Control Units: Supervise system components continuously for normal, alarm, and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.

2. Operator Commands:
   a. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.
   b. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
   c. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
   d. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
   e. Protected Zone Test: Initiate operational test of a specific protected zone.
   f. System Test: Initiate system-wide operational test.
   g. Print Reports.

3. Timed Control of Central-Station Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.

4. Automatic Control of Related Systems: Alarm or supervisory signals from certain intrusion detection devices control the following functions in related systems:
   a. Switch signal to selected monitor from closed-circuit television camera in vicinity of sensor signaling an alarm.

5. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, and sensors from central-station control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at central-station control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.

6. Programmed Secure-Access Control: System shall be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations shall override programmed settings.


C. System Component Requirements:

1. Compatibility: Detection devices and their communication features, connecting wiring, and central-station control unit shall be selected and configured with accessories for full compatibility.
D. ACS Interface Capabilities:

1. General: The ACS shall be a true Client Server architecture. All ACS software and firmware required to provide the following system functions shall be existing and fully tested ACS application software. Custom software including "ladder logic programming" and other custom application programming intended to provide the following sequences of operation are unacceptable.

2. Database Management: The system shall create and maintain a master database of all cardholder records and all system activity for all connected points.

3. Audit Trail: The ACS shall maintain an audit trail file of operator activity, and provide the ability to generate a report by operator, time and date, and type of activity (audit code). The system shall allow the operator to direct the audit trail report to screen, printer, or file. The audit trail feature shall record the following system events at a minimum:
   a. Site parameters modified.
   b. System login or logout.
   c. System restart.
   d. Cardholder added, deleted, or changed.
   e. Event added, deleted, changed, or executed.
   f. Alarm message added, deleted, or changed.
   g. Communications initiated or terminated.
   h. Field device/points added, deleted, or changed.
   i. Access privileges added, deleted, or changed.

4. Input Point Monitoring: Collect and process status information from all monitored points.

5. Alarm Annunciation: Audibly and visually annunciate all alarm, tamper and trouble conditions, and advisories.

6. Input Point Supervision: The system shall electrically supervise all 2-state and 4-state input point circuits as specified or shown on the Drawings.

7. Reports: The ACS shall fully integrate with a, dynamic report writer module that shall have access to the ACS database fields to allow users to create custom reports.
   a. Mouse driven graphical user interface with the ability to select database fields from a list of ACS database fields.
   b. User definable reports that can be saved and re-run as required without redefining the report fields and format each time the report is run. The ACS shall provide predefined reports. The predefined reports shall include the following at a minimum:
      1) Cardholder Report: Including all fields from the standard and user defined cardholder record.
      2) Input Point Report: Listing of all connected hardware input points including the point name, terminal name, and controller name to which the points are physically connected.
      3) Alarm Response Message Report: Listing of all user defined alarm response messages.
      4) Alarm Instruction Text Report: Listing of all user defined alarm instruction text.
      5) Output Point Report: Listing of all connected hardware output points including the point name, terminal name, and controller name to which the points are physically connected.
      6) Time Zone Report: Listing all user defined time zone parameters.
      7) Event Trigger Report: Listing all user defined triggers.
      8) Event Action Report: Listing all user defined event sequences.
9) Panel Report: Listing all control panel configuration settings for each sub-controller.
10) Field Device Report: Listing all terminals associated with each sub-controller panel.
11) Card Transaction History Report: Listing the transaction history filtered by cardholder name, reader name, transaction type and stop and start date and time.
12) Access Reports: Listing all access groups or cardholders with access to a specified door.
13) Reader Group Report: Listing all readers associated with a given reader group.
14) All event names that are linked to a specified event action.
15) Alarm History Report: Listing the alarm history filtered by alarm input point name, and start and stop date and time.
16) Transaction History Report with the ability to filter by any one or more of the following parameters:
   a) Reader name.
   b) Start date.
   c) Start time.
   d) End date.
   e) End time.
   f) Transaction type:
      i) Reader up.
      ii) Reader down.
      iii) System restart.
      iv) Facility code error.
      v) Card event activated at a keypad reader.
      vi) Card event deactivated at a keypad reader.
      vii) Alarm set.
      viii) Alarm reset.
      ix) Alarm acknowledged at a keypad reader.
      x) Controller tamper alarm set.
      xi) Controller tamper alarm reset.
      xii) Door open alarm.
      xiii) Duress alarm.
      xiv) PIN code retry alarm.
      xv) Forced door alarm.
      xvi) Controller AC power fail.
      xvii) Controller battery low.
      xviii) Controller tamper.
      xix) Reader AC power fail.
      xx) Reader tamper alarm.
      xxi) Alarm open.
      xxi) Alarm short.

8. Online Help System: The ACS shall provide online help, which shall be available at any time and from any active screen with single-key or mouse-click operation.
9. Operator Menu Access: The operator password shall control which menu items that the individual operator may access. It shall also be possible to restrict operators such that certain specified menu commands do not appear on the screen, or are grayed-out (disabled) for a given operator. All user passwords are fully encrypted, even while being stored and transmitted across the network.

10. Alarm Input Point Reporting Delay: The ACS shall allow the operator to apply an input point reporting delay period from 0-60 seconds for each input point terminal. The default setting for each input point reporting delay shall be 0 seconds.

11. Alarm Input Point Suppression: The ACS shall provide an alarm input point suppression facility such that the operator may define a time zone suppression period for each individual input point. Alarm conditions for suppressed input points shall not be recorded or archived by the system; however, trouble conditions will be recorded.

12. Alarm Graphics: The alarm-graphics portion of the system shall provide dynamic color alarm graphic maps on the workstation with the following functions:
   a. User definable graphic maps to depict input and output point conditions, reader status, and sub-map attachments in the ACS.
   b. The ACS shall support the importing of most bitmap file format graphics produced with any graphic drawing program such as .TIF, .BMP or .JPG file format. Vector file formats are not acceptable.
   c. The ACS map program shall support the importing of most bitmap file format graphics to produce custom icons for all map attachments (input, output, reader, etc.).
   d. The map display window shall have Home, Previous and Up level buttons for rapid movement among map levels. It shall also provide map selection and size adjustment lists.
   e. The ACS software shall be capable of storing a number of graphic maps. The quantity shall be limited by available hard disk storage space only.
   f. The ACS shall provide a palette that includes six categories of pre-defined alarm map icons:
      1) Input: Representing a user-defined alarm input point located anywhere in the system. The input point icon shall flash, change color, and the computer's internal sounder shall beep when an alarm condition exits. It shall be possible to click on the icon to respond to the alarm condition or move directly to the alarm queue window to respond to the alarm. Each alarm-input icon shall have a pop-up box that indicates the point's current state (open, short, alarm/active, secure).
      2) Output: Representing a user defined output point located anywhere in the ACS. It shall be possible to click on the icon to set or reset the output point. In addition, it can display the set or reset status of point.
      3) Map Layer: Representing that lower level maps associated with the top layer map exist in the system. It shall be possible to navigate through the map layers by clicking on the map layer (up and down) icons.
      4) Reader Terminals: Reader icons shall have the capability of displaying: held open, forced open, locked, unlocked, unknown, override, up and down.
      5) Panels: Representing a system panel controlled by the ACS. Panel icons shall have the capability of displaying the up or down status of the panel.
      6) I/O Terminals: I/O terminal icons shall have the capability of displaying the up or down status.
E. Alarm Handling: The alarm handling portion of the system, which consists of the point contacts, and the Alarm Monitoring Window shall provide the following functions:

1. The Alarm Monitoring Window shall be capable of being sorted by any column. It shall also have displayed the total number of alarms in the queue and the number which are pending.
2. The Alarm Monitoring Window shall have the capability to bring up the map to the input, which is highlighted in the window.
3. User definable alarm message/instructions description. The system shall provide the ability to assign an alarm message/instructions to each state of an input point (‘Open’, ‘Short’, ‘Alarm/Active’, and ‘Secure’).
4. Alarm Message "Pick List": All alarm message names and associated descriptions shall appear in the form of a pick list from which the operator may select an appropriate alarm name and message from all alarm messages defined in the database by the operator.
5. Alarm Input Points: The system shall support up to 17,000 alarm-input points.
6. Alarm Input Point Maintenance: The system shall provide the option for the operator to ‘Add’, ‘Edit’, or ‘Delete’ an alarm input point. The ‘Delete’ option shall require the user to confirm deletion of input point(s). All maintenance functions shall be logged to the audit trail and archived to hard disk of the host PC.
7. The system shall support both 2-state and 4-state alarm input point monitoring as called for in this Specification or as shown on the Drawings.
8. Alarm Priority: The system shall provide an alarm priority queue from 0-9. Individual wave sound assignment based on alarm priority shall be possible.
9. Alarm Popup: Alarm inputs that are designated, as "pop-up" by the operator shall take priority over any active "non-alarm" window. If the operator is viewing a non-alarm window when a popup alarm occurs, the alarm queue window shall be automatically placed on top all other windows to allow the operator to respond to the alarm condition.
10. Alarm Instruction Display: The ACS shall provide a window with up to ten lines of user defined instructions, which shall tell the operator how to respond to a selected alarm.
11. Alarm Condition History Display: The ACS shall provide a window displaying the previous states of the alarm point with a time and date stamp of each condition.
12. Alarm Response Entry: The ACS shall provide a window in which the operator may enter free form text up to 255 characters describing how he/she responded to a given alarm.
13. The operator shall also have the ability to select from a user defined list of pre-defined response descriptions.
14. The alarm instruction display, alarm condition history display, and the alarm response entry box shall all be a part of one summary window. Separate windows or applications to support any of these three functions is unacceptable.

F. Event Processing:

1. Panel Card Events: The ACS shall provide the capability for the user to define a panel card event, which may be executed by a cardholder at a reader equipped with a keypad. For each ‘card event’, the user may define the following data:
   a. Alphanumeric event name (numeric identifier only is unacceptable).
   b. Access code to control the triggering of the event (card activated event).
   c. Event trigger type (card only, card + PIN, card + PIN + code, card + code, void card).
   d. Event Privilege level (0-7).
   e. Duration of the event execution (0-1440 minutes).
   f. Input point group to be suppressed or not.
   g. Output point group to be activated or not.
   h. Door strike operation enabled/disable.
   i. Reset panel alarm relay.
2. Host Events - Triggers: The ACS shall provide the operator with a scrolling list of the following event sequence triggers as a minimum that may be combined with the event sequence logical operators listed below to program a custom sequence of events. The ACS shall be delivered with this entire listed functionality whether or not these features are implemented by the user upon initial installation.

   a. Anti-passback timer on.
   b. Executive Privilege grant of access.
   c. Host computer grant of access.
   d. Invalid In-X-It status.
   e. Invalid badge.
   f. Invalid badge time zone.
   g. Invalid keypad event.
   h. Invalid event privilege level.
   i. Invalid issue level.
   j. Invalid PIN code entry.
   k. Invalid reader.
   l. Invalid reader time zone.
   m. Local controller grant of access.
   n. Soft In-X-It violation.
   o. Card event activated.
   p. Card event de-activated.
   q. Timed override disabled.
   r. Timed override enabled.
   s. Timed override expired.
   t. Keypad event activated.
   u. Keypad event de-activated.
   v. Alarm point set.
   w. Alarm point reset.
   x. Alarm point short.
   y. Alarm point open.
   z. Reader up.
   aa. Reader down.
   bb. Facility code error.
   cc. Timed override disabled by host.
   dd. Timed override enabled by host.
   ee. System restart.
   ff. Panel online.
   gg. Panel offline.
   hh. Converter tamper.
   ii. Date.
   jj. Time.
   kk. Start time zone period.
   ll. End time zone period.
   mm. Event Counters (32 available).

3. Host Events - Actions: The ACS shall provide a scrolling list of the following event sequence actions as a minimum, and allow the user to attach one or more actions to one or more of the event sequence triggers listed above to program a custom sequence of events.

   a. Enable anti-passback.
   b. Disable anti-passback.
c. Unlock door control relay.
d. Lock door control relay.
e. Enable timed override of door control relay.
f. Set time zone for PIN code suppression.
g. Set time zone for reader.
h. Set time zone for reader override.
i. Enable reader override.
j. Disable reader override.
k. Enable soft In-X-It.
l. Disable soft In-X-It.
m. Enable local timed override.
n. Disable local timed override.
o. Lock all doors.
p. Unlock all doors.
q. Enable history upload.
r. Disable history upload.
s. Include time zone in access decision.
t. Ignore time zone in access decision.
u. Set controller relay.
v. Reset controller relay.
w. Enable input point group.
x. Disable input point group.
y. Set output point group.
z. Reset output point group.
aa. Display a user defined message in a pop-up window.
bb. Print user defined message on any printer.
c. System Database backup.
dd. System Panel Download.
cc. Display map.
ff. Event Counters.

4. Logical Operators For Trigger Conditions: The ACS shall provide a scrolling list of the following logical operators for event trigger conditions:
   a. = (Equal to).
   b. != (not equal to).
   c. > (Greater than).
   d. < (Less than).
   e. >= (Greater than or equal to).
   f. <= (Less than or equal to).

5. Logical Operators For Triggers: The ACS shall the provide the following event trigger logical operators to allow the user to attach one or more of the logical operators with one or more of the event triggers and card actions listed above to program a custom sequence of events.
   a. And.
   b. Or.

G. Time Zones: The ACS shall provide the capability for the user to define time zones with the following identification and configuration parameters:
   1. Alphanumeric name.
   2. Alphanumeric description.
3. Allowance for up to eight periods, four active and four inactive, during each day of the week and each of three different holiday types.
4. Any day of the year may be designated as a holiday; each defined as one of three holiday types.

H. Communications:
1. Should the network controller(s) lose communications with the Host, the network controllers shall continue to control access and monitor inputs for all connected points. Local history of all transactions shall be buffered at the network controller and automatically uploaded to the Host for alarm reporting and long-term historical storage once communications is re-established.

I. User Defined Cardholder Database Fields: The system shall support up to 128 user defined data fields, which may be used to store information for each cardholder. Each field may be of a type: alphanumeric text, numeric, date, toggle (Yes/No). The ACS shall provide standard menu items, which shall allow the operator to define these cardholder database fields at any time. The system shall remain online while user defined cardholder database fields are added or edited. It shall be possible, using standard ACS system menu commands to report on all user defined cardholder fields. Database shall be ODBC compliant.

J. Event and Transaction History: The ACS shall maintain a record of all alarm, card transaction, and system exceptions which take place, and provide a means for a user to access this information. It shall be possible to print information in the log in real-time or by a report.

K. Anti-Passback Control: The ACS shall provide the capability to prevent more than one person from gaining access to a controlled area by recognizing when a cardholder who is granted access is passing back the card to another person to use the same card to gain access. If so programmed, an alarm may be generated if the anti-passback rules are violated by the cardholder. It shall be possible to define on a reader by reader basis, which readers are subject to anti-passback rules.

L. Duress Processing: The ACS shall permit cardholders to indicate that they are requesting access to an area under some forced or duress situation. An alarm may be generated if a duress condition occurs, and the cardholder will be granted access.

M. Real Time System Activity Window: A real time system activity monitor window shall be available for display on any OWS screen whenever the ACS host is online. The real time window shall have the following capability:
1. Be able to selectively display the following items at the operator's discretion:
   a. Input point alarms.
   b. System Exception messages.
   c. Access Grant.
   d. Access Deny.
   e. Access Trace.
   f. Entry/Exit Central Mode of operation.
   g. Audit Trail.
2. Be able to toggle the display on and off.

N. System Status Display. The ACS shall provide a dynamic system status summary display that graphically indicates the following status information, filtered by panel or terminal. All status display information shall be summarized in a single window.
1. Terminal up/down.
2. Panel up/down.
3. State of input points (alarm, secure, short, open).
4. Indication of whether each sub-controller, terminal, reader is disabled or not reporting.

O. Alarm Routing. The ACS shall provide the ability for the user to define which input points or groups of input points are displayed on specific ACS Operator Workstations. The system shall provide a report showing which input points are routed to each OWS.

P. Real Time Printer. The ACS shall be capable of printing to a network accessible printer as well as printing from an LPT port.

Q. BAS/ACS Integration. Allow the ACS to interface the districts Ethernet network via TCP/IP to the BAS workstations. It shall further allow the BAS workstation(s) to view and acknowledge alarms and control output functions in real time. This shall allow the operator to use the BAS workstation running the graphics to view and interact with alarms generated from the ACS.

1.11 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Firms regularly engaged in manufacturer of professional quality access control systems, components and accessories, of types, capacities and characteristics required, whose products have been in satisfactory use in similar service for not less than two (2) years.

B. Supplier's Qualifications:
   1. Engage an experienced product supplier who is a factory-authorized sales and service representative regularly engaged in the design and installation of such systems to oversee the installation, troubleshoot and make final connections at headend equipment.
   2. Supplier shall have represented the product and components being installed for a minimum of five (5) years.

C. Installer Qualifications:
   1. Firm with at least five (5) years of successful installation experience with projects installing access center systems equipment similar to that required for this project.
   2. Refer to Division 01 Section "Definitions and Standards" for definition of experienced Installer. Upon requires submit evidence of such qualifications to the Architect/Engineer.

D. Electrical Component Standard: Provide work complying with applicable requirements of NFPA 70 “National Electrical Code.”

E. All system and components shall be Underwriters Laboratories listed and labeled.

F. EIA Compliance: Comply with the following Electronics Industries Association Standards:
   1. UL Compliance: Comply with requirements of UL.

1.12 DELIVERY, STORAGE, AND HANDLING

A. Deliver products in factory containers. Store in clean, dry space in original containers. Protect products from fumes and construction traffic. Handle carefully to avoid damage.

PART 2 - PRODUCTS

2.1 SOFTWARE REQUIREMENTS

A. The software shall have an installed capacity to accommodate the following at a minimum:
   1. A central database on the host server able to support up to 100,000 badges maximum.
2. Unlimited numbers of access groups.
3. Unlimited number of password groups each with an unlimited number of operator passwords.
4. Up to 17,000 2-state alarm input points, or up to 8,000 4-state alarm input points (or any combination in-between).
5. Up to four (4) operator workstation terminals (OWSs) connected to a Host server via an Ethernet TCP/IP network.
6. Central online data storage of 500,000 historical transactions, expandable as system resources allow, with a local panel storage capability of up to 100,000 cardholders and 75,000 events.
7. Ten (10) levels of alarm priority.
8. A minimum of ten (10) individual badge numbers per cardholder. Each badge shall be tracked separately.
9. Eight (8) issue levels per card, only one of which shall be active at any given time.
10. One Hundred Twenty Eight (128) user-defined cardholder fields. The system shall be capable of reporting on any or all of the user-defined fields. Each user-defined field may be defined by the user as alphanumeric, numeric, date, or logical (yes/no).

B. System Software:
1. The Host server operating system shall be Microsoft Windows® 10. It shall have multi-tasking and multi-user capability and support workstations with Windows 10.
2. The system database shall be SQL Server, Version 5.7.
3. The ACS software features shall be fully documented in the form of a complete user’s manual including operation and installation sections, and a detailed description of the major ACS functions.

C. The ACS shall be capable of partitioning (segmenting) the database which must include at least, but not limited to, the following items:
1. Cardholders.
2. Badges.
3. Time zones.
4. Holidays.
6. Panels.
7. Readers/Terminals.
8. Workstations.

2.2 PRODUCT -- GENERAL
A. Manufacturers:
1. Genetec is Basis of Design.
2. All access control hardware and software shall be of a single manufacturer including Host system, controller panels, and input and output terminal modules.

2.3 HARDWARE REQUIREMENTS
A. Network Controllers:
1. The Network Controllers shall be a fully stand-alone processor capable of making all access control decisions without the involvement of the Host Server based on a set of parameters passed to the sub-controller from the host.
a. The Network Controllers shall support sixteen (16) card readers in addition to 20% additional capacity for future growth.

b. Memory Requirements:
   1) Minimum number of cards: 12,000 expandable to 100,000.
   2) Minimum number of historical transactions: 5,000 expandable to 45,000 at full card capacity.

c. The controller shall require no firmware changes and shall use flash memory modules to provide non-volatile storage of both data and operational code.

d. Each controller shall be provided with built-in hardware to support hard-wired communications between the controller(s) and readers of up to 4000 feet.

e. Communications between the controller(s) and the host server shall be via Ethernet TCP/IP at 10Mbps minimum. There shall be an alternate communications path to the host via a secondary IP address such that in the unlikely even the primary IP address/network is down an alternate communications path may be established.

f. An alarm summary relay shall be built-in to the controller motherboard. The alarm relay shall be activated whenever a connected alarm point transfers to the alarm state and whenever soft alarms become active.

g. A tamper switch shall be attached to the inner surface of the controller enclosure. The tamper switch shall change state whenever the enclosure door is opened to signal the ACS of the condition. The tamper switch input shall be user programmable to be suppressed, to be recognized as an input point to be process by the alarm queue at the host computer, to printout at an optional printer connected directly to the controller, and to activate the alarm summary relay described above.

h. The standard AC linear power supply version of the controller shall include a battery module to back-up the controller’s applications programs and database for 30 days after the failure of the primary AC power service. The controller database, the time clock, the transaction history, and all operator entered parameters shall be backed-up by the battery.

i. The controller shall provide built-in LED to indicate whether the controller is properly communicating with the host computer.

j. Alarm monitoring and Output Control terminal boards. Intelligent alarm monitoring and output control terminal boards shall be plug-in modules to the Network Controllers with the following functionality:
   1) Sixteen 2-state alarm input points.
   2) Eight 4-state supervised alarm input points.
   3) Eight 2-state alarm input points and eight SPDT output relays.
   4) Eight 4-state supervised alarm-input points and eight SPDT output relays.

2. Signature capture device shall be connectable via a serial port interface communicating at 9600 BPS. Signature capture device shall be able to display the signature at the capture pad as well as on-screen.

3. Video Camera shall include fully software-controlled auto-focus and zoom capabilities to manual focus without zoom. Each camera option shall include necessary hardware, i.e. stand, data cable, and light source, as appropriate. The video capture cards associated with each camera shall offer crop capabilities within the software interface.

4. Manufacturer:
   a. Genetec Controller – LP1502
   b. Genetec Dual Reader Input – MR52
   c. No Equal
2.4 POWER SUPPLIES

1. Input 115VAC, 60Hz, 2.7A
2. 24VDC output
3. Sixteen (16) fuse protected outputs
4. Outputs are rated @ 3.5A
5. Operating: 0° C to 49° C (32° F to 120° F)
6. Storage: -20° C to 70° C (-4° F to 158° F)
7. Manufacturer: Altronix eFlow102NB

2.5 READERS – VERIFICATION DEVICES

A. General:

1. All readers shall be configured with the reader electronics mounted separately, on the "secure" side of the door such that only the reader head/keypad and pilot lights are mounted in the reader housing on the "entry" side of the door.
2. All readers shall support the following technologies:
   a. Multi-Technology.
3. All readers shall be in compliance with the following standards:
   a. ISO 14443A.
   b. ISO 14443B.
   c. ISO 15693.
   d. All readers shall be multi-frequency capable.
      1) 125 KHz.
      2) 13.56 MHz.

B. SmartCard Technology with Proximity Capability - Furnish and install the reader style as shown on the Drawings or as called for in this Specification:

1. Proximity Reader:
   a. The reader shall be integrated and contain all reader electronics inside a single polycarbonate enclosure; exterior, vandal proof, weatherproof housing.
   b. The reader shall operate when mounted on a variety of surfaces including metal. Maximum read range degradation when mounted on a metal surface shall be 50 percent.
   c. The reader shall contain an integral color LED and audio tone to indicate if the card has been successfully read.
   d. The reader shall be 3.3 inch x 4.8 inch x 1 inch maximum.
   e. Read range shall be up to 8 inches.
   f. The reader shall be rated for normal operation from -13 to 150 degrees F.
   g. Manufacturer: HID RP40 (920PTNNEK000)

2. SmartCard Proximity Reader with Keypad:
   a. Provide proximity reader with integrated keypad in polycarbonate enclosure for outdoor use. An LED shall flash green and a beeper shall sound indicating that the card number and keypad passcode has been successfully read. Integral tamper switch shall provide notification of reader tampering. Read range shall be up to 24 inches. The reader shall be rated for normal operation from -13 to 150 degrees F.
   b. Manufacturer: HID RP40K
3. Biometric Reader:
   a. Provides 1:1 fingerprint verification by requiring associated cardholders be present by matching their fingerprint to the stored fingerprint image.
   b. Measures 5.63 inch x 6.63 inch x 2.63 inch with charcoal gray body.
   d. Keypad, LCD Display, Real Time-Clock.
   e. Iris ID iCAM7000 series

2.6 SMARTCARDS
   A. System shall provide full compatibility with contactless SmartCards read/write technology.
   B. Digital Proximity Command Key (CARD):
      1. Single coil passive proximity card.
      2. Multiple technologies supported: proximity, magnetic stripe, bar code, photo ID.
      3. ISO Compliant: IEC 15693
      4. Memory capacity range 64 to 64K bytes.
      5. Unique numeric encoded data embedded in circuit of card.
      6. Active circuit cards (requiring batteries) are not acceptable.
   C. Polyester, Rigid Card Wipe Magnetic Stripe, Bar Code:
      2. Hole punch for vertical or horizontal image display.
         a. Thickness: .032 inches.
         b. Length: 3.32 inches.
         c. Width: 2.125 inches.

2.7 ELECTRIC STRIKE
   A. Electric strike/lock release provided by hardware manufacturer. Connections by Division 26. Interface door electrical strike release system to local card access control panel at the local doors terminal cabinet serving that area.

2.8 DOOR LATCH NOTIFICATION
   A. Provided by door hardware manufacturer and connected by Division 26.

2.9 SECURITY OVERRIDE DEVICE
   A. Provided by door hardware manufacturer and connected by Division 26.

2.10 DOOR CONTACTS
   A. Provide, where shown on Drawings, UL listed magnetic flush mounted contacts and magnets. Each contact shall be provided with matching magnet. All contacts shall be hermetically sealed for long term 10,000,000 cycle contact. Switch contacts shall be of the reed blade type with rhodium plating eliminating cold-welding; sticking and resistance build-up. All switches shall be 100 percent factory tested prior to installation. Coordinate with door frame manufacturer.
   B. Manufacturer:
      1. Interlogix 1076C-M (Recessed)
      2. Interlogix 1125TW-M (Fire Rated Opening)
3. Interlogix 2505A-L (Surface Mount/Gate)
4. Interlogix 2205A-L (Overhead)

2.11 REQUEST TO EXIT DEVICES
A. Motion Sensors: Passive infrared type designed for hands-free operation.
   1. Coverage Pattern: Provide adjustable coverage pattern using masking kit. Sensor shall have adjustable aiming of 14 degrees vertically.
   2. Provide a walk test/activation LED indicator.
   3. Relay latch time adjustable to 60 seconds. Provide two (2) Form C contacts rated 1 amp at 30 VDC for resistive loads.
   4. Sensors shall be RFI immune in the 26-900 MHz range.
B. REX devices that are part of the electrified hardware will be provided by others. Contractor shall completely wire (power and control) hardware to the access control system.
C. Manufacturer: Bosch DS160

2.12 PANIC BUTTON DEVICES
1. Nickel Plated Brass Terminals
2. Silent Actuating Button
3. Voltage Rating: 125/250
4. Current Rating: 10 Amps
5. Manufacturer: United Security Products HUB2SA (Hardwired)

2.13 WIRELESS PANIC DEVICES
1. Provide where shown on drawings.
2. Frequency 902 – 928 MHZ North America
3. Fully supervised to help ensure reliability
4. Manufacturer:
   a. Inovonics EN1223S (Single-Button Water-Resistant Pendant Transmitter)
   b. Inovonics EN1252 (Long Range Universal Wireless Transmitter)
   c. Inovonics EN1210EOL (Universal Wireless Transmitter)
   d. Inovonics EN4232MR (32-Point Wireless Receiver)
   e. Inovonics EN4216MR (16-Point Wireless Receiver)
   f. Inovonics EN4204R (4-Point Wireless Receiver)

2.14 INTRUSION ALARM PANEL
1. Programmable outputs
2. User Interface
3. Area configurations
4. Door-activated custom function
5. System users
6. Manufacturer:
   a. Bosch D7412GV4 (Control Panel)
   b. Bosch D8128D (Zone Expander)
   c. Bosch D1260 (Keypad)
   d. Bosch DS936 (PIR Motion Detector)
   e. Intellisense FG30 (Glass Break Detector)
2.15 WIRE AND CABLE
   A. Comply with requirements of Section "Wires and Cables" with stranded copper conductors. Size conductors as indicated, but not less than recommended by system manufacturer.
   B. Utilize unshielded, twisted pair cable (UTP) installed in the cable tray.
   C. Furnish and install standard manufacturer's cable assemblies for components, as recommended by the system manufacturer. Include connections for electric door strikes, card reader connections, and all required peripheral devices.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine conditions, with the installer present, for compliance with requirements and other factors affecting the performance of the security access system work.
   B. Do not proceed until satisfactory conditions have been corrected.

3.2 INSTALLATION REQUIREMENTS
   A. All consoles, terminals, and controllers shall be factory wired before shipment to the job site.
   B. Cabinet doors shall open a minimum of 170 degrees to avoid blocking personnel movement. Each door shall be equipped with a cylinder lock, a tamper switch and a piano-type hinge with welded tamperproof pins.
   C. Provisions shall be made for field wiring to enter the cabinet via standard knock-outs at the top, bottom, and sides of controller cabinets.
   D. Each wire shall be identified at both ends with the wire designation corresponding to the wire numbers shown on the wiring diagrams.
   E. All exposed wiring within the cabinets, consoles, and terminals shall be formed neatly with wires grouped in bundles using non-metallic, flame-resistant wiring cleats or wire ties.
   F. All ferrous metal work shall be painted, in accordance with the manufacturer's standards.
   G. Coordinate installation of door contacts with door/door hardware manufacturer. All wiring shall be concealed within door frame and fished/routed within building walls, where not accessible with conduits.

3.3 SYSTEM PROGRAMING
   A. The contractor shall be responsible for providing all setup, configuration, and programming to include data entry for the Security Management System (ACS) and subsystems. System programming for existing or new ACS servers shall not be conducted at the project site.
   B. Data Gathering
      1. Contractor shall provide Data Gathering Panel (DGP) input and output documentation packages for review
      2. The Contractor shall provide loading sheet documentation package for the associated DGP, including input and output boards for all field panels associated with the project. Documentation shall be provided in current version Microsoft Excel spreadsheets. A separate spreadsheet file shall be generated for each DGP and associated field panels.
3. The spreadsheet names shall follow a sequence that shall display the spreadsheets in numerical order according to the DGP system number. The spreadsheet shall include the prefix in the file name that uniquely identifies the project site. The spreadsheet shall detail all connected items such as card readers, alarm inputs, and relay output connections. The spreadsheet shall include an individual section (row) for each panel input, output and card reader. The spreadsheet shall automatically calculate the system numbers for card readers, inputs, and outputs based upon data entered in initialization fields.

4. All entries must be verified against the field devices. Copies of the floor plans shall be forwarded under separate cover.

5. The DGP spreadsheet shall include an entry section for the following information:
   a. DGP number
   b. First Reader Number
   c. First Monitor Point Number
   d. First Relay Number
   e. DGP, input or output Location
   f. DGP Chain Number
   g. DGP Cabinet Tamper Input Number
   h. DGP Power Fail Input Number
   i. Number of Monitor Points Reserved For Expansion Boards
   j. Number of Control Points (Relays) Reserved For Expansion Boards

   1) The DGP, input module and output module spreadsheets shall automatically calculate the following information based upon the associated entries in the above fields:

6. System Numbers for Card Readers
7. System Numbers for Monitor Point Inputs
8. System Numbers for Control Points (Relays)
9. Next DGP or input module First Monitor Point Number
10. Next DGP or output module First Control Point Number

   a. The DGP spreadsheet shall provide the following information for each card reader:

   11. DGP Reader Number
   12. System Reader Number
   13. Cable ID Number
   14. Description Field (Room Number)
   15. Description Field (Device Type i.e.: In Reader, Out Reader, etc.)
   16. Description Field
   17. DGP Input Location
   18. Date Test
   19. Date Passed
   20. Cable Type

   21. The DGP and input module spreadsheet shall provide the following information for each monitor point (alarm input):

   22. DGP Monitor Point Input Number
   23. System Monitor Point Number
   24. Cable ID Number
   25. Description Field (Room Number)
   26. Description Field (Device Type i.e.: Door Contact, Motion Detector, etc.)
   27. DGP or input module Input Location
   28. Date Test
   29. Date Passed
30. Cable Type
31. Camera Numbers (of associated alarm event preset call-ups)
   a. The DGP and output module spreadsheet shall provide the following information for each control point (output relay).

32. DGP Control Point (Relay) Number
33. System (Control Point) Number
34. Cable ID Number
35. Description Field (Room Number)
36. Description Field (Device: Lock Control, Local Sounder, etc.)
37. Description Field
38. DGP or OUTPUT MODULE Output Location
39. Date Test
40. Date Passed Cable Type
41. Camera Number (of associated alarm event preset call-ups)

C. DGP Input and Output Worksheet
1. Enter Beginning Reader, Input, and Output Starting Numbers and Sheet Will Automatically Calculate the Remaining System Numbers.
2. Footer
   a. File Name
   b. Date Printed
   c. Page Number

D. System Configuration and Data Entry:
1. The contractor is responsible for providing all system configuration and data entry for the ACS and subsystems (e.g., intercom, digital video recorders, network video recorders). All data entry shall be performed per Owner standards & guidelines. The Contractor is responsible for participating in all meetings with the client to compile the information needed for data entry. These meetings shall be established at the beginning of the project and incorporated into the project schedule as a milestone task. The contractor shall be responsible for all data collection, data entry, and system configuration. The contractor shall collect, enter, & program and/or configure the following components:

2. Physical Access control system components,
3. All intrusion detection system components,
4. Video surveillance, control and recording systems,
5. Intercom systems components,
6. All other security subsystems shown in the contract documents.

E. The Contractor is responsible for compiling the card access database for the Owner’s employees, including programming reader configurations, access shifts, schedules, exceptions, card classes and card enrollment databases.
F. Graphics: Based on REVIT as-built drawings developed for the construction project, create all map sets showing locations of all alarms and field devices. Graphical maps of all alarm points installed under this contract including perimeter and exterior alarm points shall be delivered with the system. The Contractor shall create and install all graphics needed to make the system operational. The Contractor shall utilize data from the contract documents, Contractor’s field surveys, and all other pertinent information in the Contractor’s possession to complete the graphics. The Contractor shall identify and request from the Owner, any additional data needed to provide a complete graphics package. Graphics shall have sufficient level of detail for the system operator to assess the alarm. The Contractor shall supply hard copy, color examples at least 8”X10” of each type of graphic to be used for the completed Security system. The graphics examples shall be delivered for review and approval at least 90 calendar days prior to the scheduled date the Contractor requires them.

G. The Contractor is responsible for backing up the system prior to uploading new programming data. Additional programming requirements are provided as follows:

1. Programming for New ACS Server: The contractor shall provide all other system related programming. The contractor will be responsible for uploading personnel information (e.g., ID Cards backgrounds, names, access privileges, personnel photos, access schedules, personnel groupings) along with coordinating with Resident Engineer for device configurations, standards, and groupings. Owner shall provide database to support Contractor’s data entry tasks. The contractor shall anticipate a weekly coordination meeting and working with Owner to ensure data uploading is performed without incident of loss of function or data loss.

2. Programming for Existing ACS Servers: The contractor shall perform all related system programming except for personnel data as noted. The contractor will not be responsible for uploading personnel information (e.g., ID Cards backgrounds, names, access privileges, access schedules, personnel groupings). The contractor shall anticipate a weekly coordination meeting and working alongside of Owner to ensure data uploading is performed without incident of loss of function or data loss. System programming for ACS servers shall be performed by using the Contractor’s own server and software. These servers shall not be connected to existing devices or systems at any time.

H. The Contractor shall identify and request from the Owner, any additional data needed to provide a complete and operational system as described in the contract documents.

I. Contractor and owner coordination on programming requires a high level of coordination to ensure programming is performed in accordance with Owner requirements and programming uploads do not disrupt existing systems functionality. The contractor shall anticipate a minimum a weekly coordination meeting. Contractor shall ensure data uploading is performed without incident of loss of function or data loss.

3.4 SYSTEM WIRING

A. Provide system and device wiring as recommended by the manufacturer. All wiring shall be concealed. Route system cabling in cable tray above ceiling. Install in surface raceway in other areas.

3.5 TESTING AND COMMISSIONING

A. The Contractor shall be responsible for testing and commissioning of the installation in accordance with all applicable documents in the Contract set.

1. Testing shall be comprehensive and sufficient to demonstrate compliance with each requirement.
2. Proposed test plan shall be submitted to the Engineer and Owner’s representative for approval before commencement of final test.

3. Final tests shall be conducted in the presence of the Engineer and Owner’s representative.

4. (1) electronic copy of each item listed below shall be delivered as a part of final systems acceptance.

   a. Functional Design Manual: The functional design manual shall identify the operational requirements for the entire system and explain the theory of operation, design philosophy, and specific functions. A description of hardware and software functions, interfaces, and requirements shall be included for all system operating modes. Manufacturer developed literature may be used; however, shall be produced to match the project requirements.

   b. Equipment Manual: A manual describing all equipment furnished including:

      1) General description and specifications; installation and checkout procedures; equipment electrical schematics and layout drawings; system schematics and layout drawings; alignment and calibration procedures; manufacturer’s repair list indicating sources of supply; and interface definition.

   c. Software Manual: The software manual shall describe the functions of all software and include all other information necessary to enable proper loading, testing, and operation. The manual shall include:

      1) Definition of terms and functions; use of system and applications software; procedures for system initialization, start-up, and shutdown; alarm reports; reports generation, database format and data entry requirements; directory of all disk files; and description of all communications protocols including data formats, command characters, and a sample of each type of data transfer.

   d. Operator’s Manual: The operator’s manual shall fully explain all procedures and instructions for the operation of the system, including:

      1) Computers and peripherals; system start-up and shutdown procedures; use of system, command, and applications software; recovery and restart procedures; graphic alarm presentation; use of report generator and generation of reports; data entry; operator commands’ alarm messages, and printing formats; and system access requirements.

   e. Maintenance Manual: The maintenance manual shall include descriptions of maintenance for all equipment including inspection, recommend schedules, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

   f. Spare Parts & Components Data: At the conclusion of the Contractor’s work, the Contractor shall submit to the Owner a complete list of the manufacturer’s recommended spare parts and components required to satisfactorily maintain and service the systems, as well as unit pricing for those parts and components.

   g. Operation, Maintenance & Service Manuals: The Contractor shall provide two (2) complete sets of operating and maintenance manuals in the form of an instructional manual for use by the Owner. The manuals shall be organized into suitable sets of manageable size. Where possible, assemble instructions for similar equipment into a single binder. If multiple volumes are required, each volume shall be fully indexed and coordinated.

   h. Equipment and Systems Maintenance Manual: The Contractor shall provide the following descriptive information for each piece of equipment, operating system, and electronic system:
1) Equipment and/or system function.
2) Operating characteristics.
3) Limiting conditions.
4) Performance curves.
5) Engineering data and test.
6) Complete nomenclature and number of replacement parts.
7) Provide operating and maintenance instructions including assembly drawings and diagrams required for maintenance and a list of items recommended to stock as spare parts.
8) Provide information detailing essential maintenance procedures including the following: routine operations, trouble shooting guide, disassembly, repair and re-assembly, alignment, adjusting, and checking.
9) Provide information on equipment and system operating procedures, including the following: start-up procedures, routine and normal operating instructions, regulation and control procedures, instructions on stopping, shut-down and emergency instructions, required sequences for electric and electronic systems, and special operating instructions.

5. Manufacturer equipment and systems maintenance manuals are permissible.
   a. Project Redlines: During construction, the Contractor shall maintain an up-to-date set of construction redlines detailing current location and configuration of the project components. The Contractor will provide access to redline documents anytime during the project for review and inspection by the Owner. Master redlines shall be neatley maintained throughout the project and secured under lock and key in the contractor's onsite project office. Any project component or assembly that is not installed in strict accordance with the drawings shall be so noted on the drawings. Prior to producing Record Construction Documents, the contractor will submit the Master Redline document to the Owner for review and approval of all changes or modifications to the documents. Field drawings shall be used for data gathering & field changes. These changes shall be made to the master redline documents daily. Field drawings shall not be considered “master redlines”.

B. Contractor’s Field Testing (CFT)

1. The Contractor shall calibrate and test all equipment, verify operation, place the integrated system in service, and test the integrated system. The Contractor shall test all security systems and equipment, and provide written proof of a 100% operational system before a date is established for the system acceptance test. Documentation package for CFT shall include completed (fully annotated details of test details) for each device and system tested, and annotated loading sheets documenting complete testing to Owner for approval. CFT test documentation package shall conform to submittal requirements outlined in this Section. The Contractor’s field testing procedures shall be acceptable to owner. The Contractor shall provide the Owner with a written listing of all equipment and software indicating all equipment and components have been tested and passed. The Contractor shall deliver a written report to the Owner stating the installed complete system has been calibrated, tested, and is ready to begin performance verification testing; describing the results of the functional tests, diagnostics, and calibrations; and the report shall also include a copy of the approved acceptance test procedure. Performance verification testing shall not take place until written notice by contractor is received certifying that a contractors field test was successful.

2. Performance Verification Test (PVT)
3. Test team:
   a. After the system has been pretested and the Contractor has submitted the pretest results and certification to the Owner, then the Contractor shall schedule an acceptance test to date and give the Owner written notice as described herein, prior to the date the acceptance test is expected to begin. The system shall be tested in the presence of the Owner’s representative, an OEM certified representative, representative of the Contractor and other approved by the Engineer. The system shall be tested utilizing the approved test equipment to certify proof of performance, FCC, UL and Emergency Service compliance. The test shall verify that the total system meets all the requirements of this specification. The notification of the acceptance test shall include the expected length (in time) of the test.

4. The Contractor shall demonstrate the completed ACS complies with the contract and Owner requirements. In addition, the Contractor shall provide written certification that the system is 100% operational prior to establishing a date for starting PVT. Using approved test procedures, all physical and functional requirements of the project shall be demonstrated and shown. The PVT will be stopped and aborted as soon as 10 technical deficiencies are found requiring correction.

5. The PVT shall not begin until receipt of written certification that the Contractor’s Field Testing was successful. This shall include certification of successful completion of testing as specified in paragraph “Contractor’s Field Testing”, and upon successful completion of testing at any time when the system fails to perform as specified. Upon termination of testing by the Owner or Contractor, the Contractor shall commence an assessment period as described for Endurance Testing Phase II.

6. Upon successful completion of the acceptance test, the Contractor shall deliver test reports and other documentation, as specified, to the Resident Engineer prior to commencing the endurance test.

7. Additional Components of the PVT shall include:
   a. System Inventory
      1) All Device equipment
      2) All Software
      3) All Logon and Passwords
      4) All Cabling System Matrices
      5) All Cable Testing Documents
      6) All System and Cabinet Keys
   b. Inspection

8. Contractor shall record an inspection punch list noting all system deficiencies. The contractor shall prepare an inspection punch list format for Owners approval.

9. As a minimum the punch list shall include a listing of punch list items, punch list item location, description of item problem, date noted, date corrected, and details of how item was corrected.
C. Endurance Test

1. The Contractor shall demonstrate the specified probability of detection and false alarm rate requirements of the completed system. The endurance test shall be conducted in phases as specified below. The endurance test shall not be started until the Owner’s Representative notifies the Contractor, in writing, that the performance verification test is satisfactorily completed, training as specified has been completed, and correction of all outstanding deficiencies has been satisfactorily completed. The Owner may terminate testing at any time the system fails to perform as specified. Upon termination of testing, the Contractor shall commence an assessment period as described for Phase II. During the last day of the test, the Contractor shall verify the appropriate operation of the system. Upon successful completion of the endurance test, the Contractor shall deliver test reports and other documentation as specified to the Owner prior to acceptance of the system.

2. Phase I (Testing): The test shall be conducted 24 hours per day for 15 consecutive calendar days, including holidays, and the system shall operate as specified. The Contractor shall make no repairs during this phase of testing unless authorized in writing by the Owner. If the system experiences no failures, the Contractor may proceed directly to Phase III testing after receiving written permission from the Owner.

3. Phase II (Assessment):
   a. After the conclusion of Phase I, the Contractor shall identify all failures, determine causes of all failures, repair all failures, and deliver a written report to the Owner. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and recommend the point at which testing should be resumed.
   b. After delivering the written report, the Contractor shall convene a test review meeting at the job site to present the results and recommendations to the Owner. The meeting shall not be scheduled earlier than five (5) business days after the Owner receives the report. As part of this test review meeting, the Contractor shall demonstrate all failures have been corrected by performing appropriate portions of the performance verification test. Based on the Contractor’s report and the test review meeting, the Owner will provide a written determine of either the restart date or require Phase I be repeated.

4. Phase III (Testing): The test shall be conducted 24 hours per day for 15 consecutive calendar days, including holidays, and the system shall operate as specified.

5. Phase IV (Assessment):
   a. After the conclusion of Phase III, the Contractor shall identify all failures, determine causes of all failures, repair all failures, and deliver a written report to the Owner. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and recommend the point at which testing should be resumed.
After delivering the written report, the Contractor shall convene a test review meeting at the job site to present the results and recommendations to the Owner. The meeting shall not be scheduled earlier than five (5) business days after receipt of the report by the Owner. As a part of this test review meeting, the Contractor shall demonstrate that all failures have been corrected by repeating appropriate portions for the performance verification test. Based on the review meeting the test should not be scheduled earlier than five (5) business days after the Owner receives the report. As a part of this test review meeting, the Contractor shall demonstrate all failures have been corrected by repeating appropriate portions of the performance verification test. Based on the Contractor’s report and the test review meeting, the Owner will provide a written determine of either the restart date or require Phase III be repeated. After the conclusion of any re-testing which the Owner may require, the Phase IV assessment shall be repeated as if Phase III had just been completed.

3.6 TRAINING AND INSTRUCTION

A. Upon completion of the work, and prior to acceptance of the same by the Owner, the Contractor and major equipment manufacturer’s qualified representative shall provide 40 hours of Owner instruction in four (4) hour sessions. Sessions shall include instruction on the operation and service of all Video Surveillance and Access Control equipment and controls. This instruction shall be done at the facilities’ location and convenience, and in the presence of the Architect/Engineer’s representative.

B. Training materials shall consist of the following:
   1. Formal course outline and agenda.
   2. Operator training student guide for each student.
   3. Hands-on practice with online equipment.
   4. Written examinations.

3.7 WARRANTY

A. All equipment furnished under this contract shall be warranted for a period of twelve (12) months from the date of final Engineer/Owner acceptance of the system.
   1. Respond to service requests on-site, if required.
   2. Replace or repair defective components as required.

END OF SECTION 281300
SECTION 282300 – VIDEO SURVEILLANCE SYSTEM EXPANSION

PART 1 - GENERAL

1.1 SUMMARY

A. Provide Genetec Omnicast Video Surveillance Management System to accommodate devices as shown on Drawings. Provide and install complete, fully functional, IP, video surveillance system with real-time recording, monitoring and playback. Install new fixed and PTZ IP cameras, interior and exterior as shown on the Drawings. Provide housings, wall / ceiling / pole / parapet mounts, monitors, networked video recorders, time/data generators, controls, signal equipment, transmission lines, software, racks and accessories. Provide server for local storage. Integrate with existing Video Surveillance System for a single platform.

1. System shall have client to multi-server capability allowing a single station and software package to view any/all camera simultaneously.
2. Upgrade software to accommodate new devices.
3. Provide licensing for new devices.
4. Include SMA as required by manufacturer to maintain ongoing support for cameras provided.
5. Provide network video storage that is configured in a redundant array of independent disks (RAID) with hot swappable drives and fail over service.
6. Integrate the Video Surveillance System to the Access Control System and the Intrusion Detection system through the application layer without the need for 3rd party software or modules. Provide hardware and software components that function together for a complete integrated system.

B. Provide Video Surveillance Digital Management Systems comprised of, but not limited to, IP cameras, housings, monitors, networked video recorders, time/data generators, controls, signal equipment, transmission lines, software, racks and accessories. Provide video surveillance server to accommodate additional IP cameras and storage. Provide Enterprise software and load on new server as recommended by manufacturer.

1. Provide licensing for new devices.
2. Include SMA as required by manufacturer to maintain ongoing support for cameras provided.

C. Applications for video surveillance systems, capable of transmitting and recording transient images by means of wires/cables to single, or multimonitor displays required for project includes but not limited to the following locations:

1. Building entrances.
2. Corridors and public spaces.
3. Building exterior and parking lots
4. Stairwells.

D. Work in this section includes, but is not limited to, furnishing and installing the following equipment:

1. Video surveillance cameras.
2. Video surveillance monitors.
4. Fixed IP cameras.
5. PTZ IP cameras.
7. Fiber cabling, terminations, converters.
8. Video management software and licensing.
9. Mounting equipment and environmental enclosures.
10. Cabling, terminations, etc.
11. Power supplies.
12. Pan/tilt mechanisms.
14. Fiber optic extenders
15. Lightning / Surge Protection

E. Any other video surveillance equipment not listed above but shown or specified in the contract documents or as required for a complete operating video surveillance system.

F. Refer to applicable Division 26 sections for wires/cables, electrical raceways, and boxes and fittings required in connection with video surveillance systems.

G. Control/signal transmission media used with video surveillance systems are specified in Division 27 Structured Telecommunications Cabling System.

1.2 RELATED DOCUMENTS
A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections.

B. Requirements of the following Division 26 Sections apply to this Section:
   1. Section "Common Work Results for Electrical."
   2. Section "Basic Electrical Materials and Methods."
   3. Section "Raceways."
   4. Section "Conduit Rough-In Systems."
   5. Section "Wire Basket Cable Tray"

C. Requirements of the following Division 27 Sections apply to this Section:
   1. Section "Common Work Results for Communications."
   2. Section "Structured Telecommunications Cabling Systems."

D. Requirements of the following Division 28 Sections apply to this Section:
   1. Section "Common Work Results for Electronic Safety and Security."
   2. Section "Access Control/Intrusion Detection System."

1.3 SUBMITTALS
A. General:
   1. Submit the following in accordance with Conditions of Contract, Division 01 Specification Sections.

B. Submittals shall be provided based on specification number and be inclusive of the equipment within that section. Equipment submitted from multiple sections under a single cover, will not be reviewed.

1.4 ACTION SUBMITTALS
A. Product Data: Submit for each type of product specified.
   1. Provide manufacturer’s literature to include all information necessary to confirm that the proposed system is in complete compliance with the Specifications.
   2. Provide all information in a single, complete bound submission.
3. Table of Contents identifying equipment lists with numbered pages corresponding to equipment/device locations within submittal for quick reference.

4. System Scope of Work narrative including Sequence of Operation of all devices and system functionality, Owner meetings, Owner reviews, programming approval, milestones, and testing.

5. Equipment Information:
   a. All equipment shall be specific to this section only unless required for integration.
      1) Manufacturer’s specifications and descriptive literature.
      2) Manufacturer’s recommended installation procedures.
      3) Equipment/device quantities.
      4) Equipment/device product information sheets with submission designated, installation information, color/finish options, etc.
      5) Program information sheets.
      6) Coordination requirements with all trades.
      7) Program layout diagrams, riser diagrams, wiring diagrams, rack elevations, seismic requirements, etc. Utilize Architectural, Electrical, and Communication symbology to be consistent with Owner's standards.
      8) Deviations from specifications, if any, highlighted with specific explanation and identification requiring Architect/Engineer specific approval.
      9) Manufacturer required information for base and extended warranties including submission requirements and timeframes.
     10) Estimated equipment heat loads and power requirements. List and tabulate equipment specifically required in Telecommunications Rooms and Equipment Rooms.
     11) Submit qualifications based on quality assurance requirements for manufacturer, supplier, installer, trainer, etc.
     12) Provide secondary submittal for systems requiring programming and Owner input, review, and approval after Programming meeting, sequence of operations review, etc. Provide all information in spreadsheet format in electronic and hardcopy.
     13) Training outline.
     14) Sample test reports.

   b. Provide a list with references of at least three (3) installations of equivalent or larger systems installed within the last two (2) years with the specified products.
      1) Provide Facility location and name.
      2) Owner’s or User’s name, address, and telephone (including fax) numbers.
      3) Date of Project Start and Date of Final Acceptance by Owner.
      4) System Project Number.
      5) Brief (three paragraphs minimum) description of each system’s function, operation, and installation.

   c. Provide certification with data substantiating that products comply with requirements of the Contract Documents. Furnish UL File number with product data as submitted.

B. Shop Drawings (Submit for each):
   1. Layout Drawings:
      a. Submit scaled system layout drawings using architectural floor plans indicating head end equipment layout and dimensions. Include layout of equipment in relation to room size and other existing and new system equipment in that room. Include equipment layout and rack elevations.
1) Indicate connections to equipment supplied by others.

b. Submit scaled system layout drawings using architectural floor plans for system equipment indicating cable types, cable quantities amplifiers, electrical connections, taps, etc., as designed for this project.

1) Show device locations that correspond to the floor plans. Identify camera type and associated coverage of camera on the floor plan for review and coordination with owner.
2) Include lengths of all horizontal cables and cable type.
3) Provide building room numbers and diagrams specific to this project.
4) All panels, plates and designation strips, including details relating to terminology, engraving, finish and color.
5) Detailed wiring for connectivity of other interfaces. Differentiate clearly intersystem connections.
6) Wiring Diagrams detailing wiring for power, signal, and control differentiating clearly between manufacturer-installed wiring and field-installed wiring. Identify terminal numbers and wiring color codes to facilitate installation, operation, and maintenance.
7) Remote control panel design (to include "live" interactive electronics format).
8) All equipment racks, cabinets, consoles, tables, carts, support bases and shelves.
9) All non-factory equipment modifications.
10) Front mechanical drawings of each equipment rack.
11) System functional block drawings, including those for audio and video subsystems.
12) Cable labeling plan.
13) Grounding: Identify grounding requirements and connections to Telecommunications Grounding Busbar.
14) Differentiate between portions of equipment that are factory/vendor assembled and that which are field-installed.

C. Coordination Drawings (1):

1. Details of system including but not limited to the following:
   a. Console layouts.
   b. Control panels.
   c. Rack arrangements.
   d. Interface method to other systems or equipment.

2. Integration: Detail interconnections to other systems.

D. Camera Schedule - A camera schedule shall be developed for each camera. Contractors shall coordinate with the Froedtert Hospital Security Systems Administrator to determine camera starting numbers and naming conventions. All drawings shall identify wire and cable standardization methodology. Color coding of all wiring conductors and jackets is required and shall be communicated consistently throughout the drawings package submittal. At a minimum, the camera schedule shall include the following information:

1. Item Number
2. Camera Number
3. Naming Conventions
4. Description of Camera Coverage
5. Camera Location
6. Floor Plan Sheet Number

VIDEO SURVEILLANCE SYSTEM EXPANSION

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1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   a. Provide documentation verifying requirements identified in Quality Assurance Section.

2. Supplier Qualifications:
   a. Certification signed by officer of installation company attesting that proposed system complies with specification requirements:
      1) For multiple firms, an officer from each firm must sign.
   b. The Contractor shall be a licensed security Contractor as required within the state and jurisdiction of where the installation work is being conducted. For AHJ requirement:
      1) Copy of jurisdiction electrical license or permit.

3. Installer Qualifications:
   a. Provide documentation of certification of manufacturer, supplier, installers, project managers and instructors to be utilized on this project. Documentation to include the following:
      1) Manufacturer Training and Certifications:
         a) Submit contractual relationship or technical certification by the respective equipment manufacturers that installer is authorized by that equipment manufacturer to pass through the manufacturer’s certification and equipment warranty to the Owner. Additionally, the equipment manufacturer and Contractor shall accept complete responsibility for the design, installation, certification, operation and physical support for the system.
      b) Have a minimum of 5 manufacturer certified technicians on all products provided for this project. The technicians shall have a minimum of five (5) continuous years of technical experience in video surveillance and electronic security systems.
   b. Project Manager Resume’.

4. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation within specified hours of receipt of notification that service is needed. Submit name and address of service organizations.

5. Manufacturer’s Instructions:
   a. Manufacturer’s recommendations for installing.
   b. Provide documentation of certification of manufacturer, supplier, installers and instructors to be utilized on this project.
B. Coordination Data:
   1. Coordination Drawings:
      a. Provide trade coordination drawings of corridor ceilings with limited space where congestion with other systems may be a problem.

1.6 CLOSEOUT SUBMITTALS

A. Operations and Maintenance Data:
   1. Final Submittal Copy:
      a. Approved copy of system submittal.
      b. Provide a listing of individual product/device/equipment warranties provided from the manufacturer with expiration dates identified.
      c. Provide a complete listing of devices, installed locations with product serial numbers for product tracking.
      d. Provide all equipment and device licensing information equal to the lifetime of the product with the current system integration.
      e. Provide a complete set of equipment cut sheets, parts list, including maintenance criteria, “troubleshooting” guide, distributor information and service information for all equipment provided.
      f. Provide a complete set of instruction manuals; including complete written programming instructions, programming documentation and system set-up documentation.
         1) Provide an additional quick-start guide with all commonly used procedures for operating the system. Laminate and provide copies during training session.
      g. Provide all test results performed. Include manufacturer’s certifications that installed system complies with specification requirements.
   2. Special Warranty Information:
      a. Provide copy of all documentation including test results sent to manufacturer for system warranty.
      b. Provide all required documentation to the system manufacturer to initiate and ascertain the warranty specified.
      c. Provide warranty of the system by the system manufacturer and guaranteed for the term of the warranty.
   3. Service Contract:
      a. Provide copy of first service contract terms for Owner evaluation prior to accepting or rejecting service contract.

B. Record Documents:
   1. Operation and Maintenance Data:
      a. Include the following in emergency, operation and maintenance manuals.
         1) Three (3) final corrected copies of catalog data and shop drawings, critical spare parts list, and manufacturer’s operation and maintenance data applicable for the equipment furnished.
         2) Instructions for periodic testing.
         3) Warranty information.
2. Record Drawings:
   a. Record drawing indicating locations of all system components.
   b. Provide a revised set of system wiring diagrams upon the completion of the installation for subsequent testing of the system to show actual cable routing, connections with other systems, cable lengths, values of all equipment as installed and actual signal values as tested.
   c. Utilize architectural floor plans for system layout.

3. Training / Demonstration Video.


5. Manufacturer software CD for products provide as part of the system.

6. Provide electronic copy of system programming and configuration at time of Owner signoff. This is to include but not limited camera configurations, VMS software configuration systems for use in disaster recovery of the system.

7. Final Field Quality Control Test Reports. Document items identified in the testing section.

1.7 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturers:
   a. Firms regularly engaged in manufacture of professional quality video surveillance systems, components and accessories, of types, capacities and characteristics required, whose products have been in satisfactory use in similar service for not less than five (5) years.
   b. Provided equipment shall have a guaranteed availability for a minimum of five (5) years from the delivery date through current distribution channels.

2. Suppliers:
   a. Engage an experienced product supplier who is a factory-authorized sales and service representative regularly engaged in the design and installation of such systems to oversee the installation, trouble-shoot and make final connections at headend equipment.
   b. Supplier shall have represented the product and components being installed for a minimum of two (2) years.

3. Installers:
   a. Shall be fully capable and experienced in the installation of the systems specified, and have a minimum of five (5) years’ experience on specified manufacturers equipment
   b. Qualified and certified installers and technicians on staff and assign them to this project. The project shall be staffed at all times by Installers and Technicians who, in the role of lead crafts persons, will be able to provide leadership and technical resources for the remaining crafts persons on the project.
   c. Shall be certified by the manufacturing company(-ies) in all aspects of installation and testing of the products described within the systems specifications.
      1) Have on staff five (5) technicians with manufacturer installer certification of specified and approved equipment.
   d. Refer to Division 01 Section "Definitions and Standards" for definition of experienced Installer. Upon request submit evidence of such qualifications to the Architect/Engineer.
Installer Supervision:

1) Provide a Project Manager as a single point of contact for all activities performed under this section and related equipment sections. The Project Manager shall have a minimum of ten (10) years’ experience in design and installation. The designer must have sufficient experience in this type project(s) as to be able to lend adequate technical support to the field forces during installation, during the warranty period and during any extended warranty periods or maintenance contracts. The Project Manager, or designee thereof, shall be required to attend project meetings as required until project closeout/signoff.

2) The Project Manager shall not change without the Owner consent. The Contractor shall not employ a proposed Project Manager to whom the Owner or Engineer has made reasonable objection.

3) If, in the opinion of the Owner, the Project Manager does not possess adequate qualifications to support the project, the Owner reserves the right to require to assignment of a Project Manager whom possesses the necessary skills and experience required of this project.

Service Qualifications:

a. Firm with at least five (5) years representing, servicing, and maintaining manufacturers products installed at this location.

b. Firm with at least five (5) manufacturer trained service technicians on specified product portfolio.

c. Firm located within 100 miles and provide two (2) hours onsite response time to service request.

DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements:

1. Deliver components properly packaged in factory fabricated containers.
2. Deliver reels, racks, etc. on truck with hydraulic gate or lower carefully using hoist or fork lift. Never drop equipment.
3. Upended heavy equipment, racks, reels, etc. will often arrive damaged. Refuse or receive subject to inspection for hidden damages. Records of delivery date, manufacturer, installation date, any extenuating circumstances along with manufacturer test reports shall be kept on file.

B. Storage and Handling Requirements:

1. Store components in original cartons.
2. Material shall be stored in a secure area with a clean dry space protected from the effects of the weather and away from open fires or sources of heat.
3. Material shall be stored in an area away from construction traffic where construction equipment, falling or flying objects or other materials will not contact the components.
4. Material shall be stored in an area where chemicals, paint, or petroleum products will not be spilled or sprayed on them.
5. Equipment must not be stored sitting in direct contact with water or dampness. Equipment should be stored on flat, hard surface so that flanges do not sink into the earth. Timbers or metal supports must be placed under the red flanges to provide elevated storage away from water or damp soil.
6. Handle equipment and components carefully to avoid breakages, impacts, denting and scoring finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer. Store components in original cartons.

7. If materials are relocated, an inspection shall be made.

8. Handle equipment and components carefully to avoid breakages, impacts, denting and scoring finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer.

C. Packaging Waste Management:
   1. Dispose of all packing materials and include cost of packing materials disposal and handling as part of the base bid.

1.9 WARRANTY
A. Contractor Construction Warranty:
   1. Refer to Division 01 requirements.

B. System Warranty:
   1. Provide a one (1) warranty for the entire system.
   2. The warranty shall be backed by the manufacturer’s certified vendor.
   3. In the event that the system is being interfaced to existing equipment, that equipment warranty shall be covered by the new warranty implemented with this project.
   4. Warranty shall commence when the following construction milestones are met:
      a. Substantial Completion.
      b. Final Engineer acceptance of complete system installation.

C. Special Warranties: Manufacturer specific product/equipment warranties beyond that listed as system operation.

1.10 LICENSES
A. Expand existing Genetec Omnicast Video Surveillance System, upgrade software to current platform, Enterprise, and provide associated licensing. Provide all licenses for all equipment to operate for the lifetime of the installed equipment and system.
   1. Licenses shall not expire for the equipment or devices purchased and installed and shall not be required for extending maintenance or operation of the system.
   2. Licenses shall cover software and hardware.

1.11 PROJECT CONDITIONS
A. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   1. Control Station: Rated for continuous operation in ambient temperatures of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
   2. Interior, Controlled Environment: System components, except central-station control unit, installed in temperature-controlled interior environments shall be rated for continuous operation in ambient temperatures of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing. NEMA 250, Type 1 enclosures.
   3. Interior, Uncontrolled Environment: System components installed in non-temperature-controlled interior environments shall be rated for continuous operation in ambient temperatures of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing. NEMA 250, Type 3R enclosures.
4. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient temperatures of minus 30 to plus 100 deg F dry bulb and 20 to 100 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick. NEMA 250, Type 3R enclosures.

5. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. General: Expand and Upgrade existing Genetec Omnicast Video Surveillance System. Provide video surveillance systems, of types, sizes, capacities and electrical characteristics indicated, consisting of cameras, enclosures, monitors, media converters, time/date generators, signal transmission lines, and other components as required to accommodate new devices and as indicated in specifications. Except as otherwise indicated, provide manufacturer’s standard video surveillance system components as indicated by published product information, designed and constructed as recommended by manufacturer. Provide video surveillance systems with following functional and construction features as indicated.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering video surveillance system products which may be incorporated in the work include, but are not limited to, the following:

1. Video Surveillance Management Software Basis of Design:
   a. Genetec Omnicast-VMS

2. Video Surveillance Camera Basis of Design:
   a. Axis

2.2 HEAD-END EQUIPMENT

A. Digital Video Management System Software:

1. General Product Description:
   a. Provide a Video Management System (VMS) with an open platform, easy to use and designed with open architecture. The DVMS shall manage all the surveillance-related hardware associated with this project.
   b. An open platform is defined as a software system with published external programming interfaces that enable its use in ways beyond the scope of the original programmers. Allow other companies and developers to develop products that add additional functionality and versatility to the IP video surveillance solution.
   c. Provide a management layer to decouple software from hardware and open a connection point for options.
   d. Provide a VMS solution with the following:
      1) As support becomes available for future camera and encoder models, the DVMS shall be able to support these without the need to reconfigure the system.
2) Only native API integration is acceptable for camera interface to the VMS to allow the entire feature set of the camera available to the VMS. Integration with third party software application using an Application Programmers Interface (API). The manufacturer of the unit shall offer a Software Developers Kit (SDK) to third party manufacturers, in addition to sample modular programs with their source codes to develop their own software to control the unit’s functions. ONVIF camera integration is not acceptable.

3) Compatible with any standard TCP/IP Ethernet Network.

4) Incorporate third-party integrations such as video analytics, intercoms, intrusion detection, access control, public address, etc.

5) Provide a mobile client that is able to operate on Android and iOS mobile devices (smartphones, tablets and portable music players).

6) Allow third-party companies to develop applications to function on the IP video surveillance solution.

e. Software-based solution designed for installations that consist of multiple sites and, therefore, utilize multiple servers to run the deployment.

f. Utilize system configuration wizards and have functionality to detect hardware. Support devices from different vendors.

g. Allow an unlimited number of cameras to be connected.

h. Have the ability to run on virtualized Windows® servers.

i. Ability to store video and audio recordings on any form of storage type including internal hard drives, direct attached storage, network attached storage, storage area network, etc.

j. Support archiving for optimizing recorded data storage through data storage solutions that shall combine performance and scalability with long-term video storage.

k. Provide an alarm management function that makes it possible to manage all alarms generated by all the components on the system, including:

   1) Internal system-related events, such as motion, archiving issues and SNMP.
   2) External integrated events, including video analytics, access controlled doors that have been open too long or forced open and invalid card events, intrusion detection system alarms.
   3) Other events from third-party-developed plug-ins.

l. Feature Overview:

   1) View live images at 25 PAL / 30 NTSC + frames per second.
   2) Device control (pan-tilt-zoom with patrolling).
   3) Recording and playback.
   4) Hourly archiving schedules.
   5) Input, output and event control.
   6) Audio support for 2-way audio from microphone/speaker at operator’s PC to auxiliary speaker/microphone.
   7) Audio recording from microphones in cameras.
   8) Video export of recordings in AVI and JPEG formats.
   9) Microsoft® Active Directory support.
   10) Full viewing client of live and recorded video.
   11) Unlimited Web client access via Internet browsers at no charge without client software:

       a) Connect to VMS server.
12) Mobile Client (iOS and Android compatible):
   a) Connect to VMS server.

13) Display multiple views a single and on multiple monitors.

14) Map Function: To provide an intuitive overview of system, building(s) Campus and allow selection of camera from map support file formats jpg., gif., png., tif.

15) Alarm manager integrated with graphical map to identify alarm points:
   a) Integration with third party access control/intrusion detection systems.

16) Privacy masking to control access to cameras and views.

17) Camera navigation feature.

18) Video matrix for support of multiple monitors on VMS system.

19) Integration platform (Software Development Kit) for third-party application integration.

20) Unlimited number of recording servers per system.

21) 64 color IP cameras per recording server.

22) Dual streaming (live and recording) per camera.

23) Built-in de-warping lens support for 180 degree and 360 degree views.

24) Scheduling of PTZ camera presets.

m. System:
   1) Support for MJPEG, MPEG-4 SP, MPEG-4 ASP, MxPEG, H.264, and H.265 compression formats.
   2) Generic network camera support via universal driver.
   3) IP device brands and models directly supported via dedicated driver.
   4) Secure HTTPS camera connectivity (on supported devices) utilizing (SSL).
   5) Dual stream (live and recording) per camera.
   6) Video recording speed up on motion, event and time schedule.
   7) Built-in video motion detection (VMD).
   8) Set video motion detection per camera.
   9) Unlimited video retention time.

n. Pan-Tilt-Zoom Camera Technology:
   1) 50 presets per camera.

o. Input, output, and events.

p. Alarm management including triggering alarms, set alarm description, work instructions, customize alarms and priority levels, categories.

q. Archiving:
   1) Automatic and scheduling archiving of recordings.
   2) Keep online access to local or archived video.
   3) Parallel archiving and recording.
   4) Hourly archiving schedules.
   5) Dynamic archiving (disk spanning).
   6) Archiving to network drives.
   7) Storage overview (used vs. available space) of available storage drives.

r. Integration:
   1) Video content analysis support for third party integrations.
   2) Recording server application programming interface (API)/SDK.
   3) Client plug-in support through third party systems.
4) Open integration platform and/or Software Development Kit.
5) Generic events via TCP/IP.

s. Management:
   1) Configuration wizards for adding cameras, configuring video, set up recordings, adjusting motion detection and configure user settings.
   2) Automatic device scanning with automatic device model detection.
   3) Device replacement wizard for existing/new devices.
   4) Run servers as Windows Services.
   5) Scheduled start/stop of devices and scheduled preset camera views or PTZ ranges.
   6) Export and import of configuration data.
   7) System configuration restore points.
   8) Online and offline activation.

 t. Viewing Clients:
   1) Clients for different platforms (full viewing client, mobile client, web client).
   2) Customize access ports to viewing clients.

u. Logging:
   1) System logs, event logs, and audit logs.

v. Client Functionality:
   1) Provide the following functionality for the clients:
      a) Minimum 39 view layouts.
      b) Up to 100 view items per view.
      c) Optimized view layouts for 4:3 and 16:9 display ratios.
      d) Corridor optimized view layouts.
      e) Optimized view layouts for landscape and portrait displays.
      f) Private and shared views.
      g) Images, active HTML pages, virtual matrix, hotspots and carousels in views.
      h) Hide HTML toolbar.
      i) Controllable carousel.
      j) Overlay buttons.
      k) Full screen mode.
      l) Display views as floating window.
      m) Display views on multiple monitors.
      n) Initial default view.
      o) Automatic restore of views and windows at login.
      p) Update on motion only.
      q) Audible alerts by VMD or event.
      r) Start recording in view.
      s) Independent playback in live and playback mode.
      t) Change camera shown in view.
      u) Send video from camera to virtual matrix view.
      v) Share video image (copy to clipboard).
      w) Assign commands to keyboard shortcuts and joystick buttons.
      x) Switch to camera by number.
      y) Recording search.
      z) Time/date search.
aa) Fast search feature.
bb) Event/alert list visible in recordings.
c) Graphical timeline.
d) Adjust playback speed.
ee) Single step installer (installs full viewing client and mobile server component with DVMS).
ff) Two-way audio support.
gg) Digital zoom.
hh) Share video image.
i) Print report with comments.
jj) Privacy masking.

2) PTZ Support:
a) Preset locations.
b) Pause patrolling at manual operation.
c) Joystick compatibility.

3) Input, output and events in clients:
a) Manually activate events.
b) Manually trigger outputs.

4) Video sequence navigation feature.
5) Alarm management in full viewing client.
6) Map function.
7) Export.
8) Authentication.
9) Authorization.
10) Personalization.

w. Utilities:
1) Software manager utility.
2) Utility to detect system failures.

2. Supplemental Requirements:

a. Record (encode) and playback (up to 60 color cameras in real time and time lapse modes).
b. In playback (SEARCH mode), provide a full screen display of any of up to 4 previously recorded camera, or it can display a selection of any of the cameras in a multi-screen display.
c. Continuous, Motion Detection, Alarm, Pre-alarm, and scheduling recording modes.
d. Allow instant access to critical recordings by alarm, time, date, and camera searches.
e. In addition to camera video, shall provide the time and date, camera number, and a user programmable 16-character camera title, which is recorded to the internal hard drive.
f. Program to activate recording when a camera detects motion. Each camera shall be programmed to detect motion, including the capability to select up to 10-motion detection areas (per camera) and motion sensitivity.

1) Camera shall be capable of pre-recording a minimum of 5 seconds prior to motion activation for storage.
g. Provide duplex mode operation and record up to 60 images per second in duplex mode.

h. Recognition of image alteration via watermark; includes watermark software.

i. Include remote viewing software with recorder with no licensing requirements or user limitations.

j. Remote software allows multiple user log-ons via Ethernet and be password protected.

k. Remote software allows user to view cameras from multiple servers simultaneously.

l. Provide remote software users the ability to view live video, playback recorder video, have pan tilt zoom control, and relay capabilities.

m. Compatible with Axis, IP camera platforms. Provide API integration to camera.

B. Digital Video Management System software to support a video matrix solution supporting multiple monitors, the application must provide a tabbed environment that permits the end-user to quickly switch between several work spaces; accessing live and recorded data simply by switching between tabs with a single click. Critical data shall be accessed, monitored and managed from multiple locations. The systems open architecture platform to allow for scalability, flexibility, and future integration of advanced feature sets.

C. Provide a graphical user interface that allows users to monitor and manage any combination of IP cameras through a single digital video surveillance application. As a video matrix solution supporting multiple monitors, software shall allow for configuration and management of highly-diverse and complex security systems. Provide easy-to-use application offers quick search of recorded audio and video, while the export wizard rapidly downloads digital recordings. Software also supports third-party applications, video analytics and data transaction information. Expand existing interface to accommodate the new facility.

1. Network Health Monitoring:

   a. Provide Network Health Monitoring (NHM) to enable the use of Simple Network Management Protocol (SNMP) to monitor any VMS alongside other networked devices. Provide early warning signs of network or hardware failure to result in faster response, greater system uptime and improved resiliency. If a problem with a system does occur, users can be notified via e-mail, or other pre-defined visual and audible alert options. Software is compatible with several SNMP monitoring packages. Combine the SNMP software and the industry-standard Windows SNMP service to allow professionals to monitor their system at the IT-level in multiple ways or any third-party SNMP monitoring application.

2. Video Analytics:

   a. Analytics provided through (VMS) automates the video surveillance process.

3. Archive Utility:

   a. The Archive Utility is a flexible application that enables end-users to transfer video and audio data from any DVMS server to another storage server on the network for storage. The utility extends hard drive capacity allowing data to be archived for periods greater than one month while also minimizing search and retrieval time. The Archive Utility’s robust feature set includes event archiving, flexible scheduling, auto archive and off-site disaster recovery. Users can configure and administer entire automated archiving schemes for multiple DVMS units—on a camera-by-camera basis all from a single computer. Coordinate transfer of video from local storage to archive server.

4. Automated Online Updates:
a. Provide online updates to allow software users to download software updates and patches onto any Integral DVMS unit via the Internet. Software service that automatically delivers and uploads software patches or updates, further simplifying the process of upgrading Integral systems.

5. Import JPEG, AutoCAD, PDF’s of building floor plans. Locate selectable camera icons on floor plans which directs user to live and recorded video of selected camera.

6. Import static or HTML maps for fast navigation to cameras and premise overview.

D. Supports Video Management (VMS):
1. Software can be installed on industry standard servers.
2. Hybrid solution seamlessly integrating Analog, Encoders and the latest IP Technology.
3. Supports third party applications, video analytics and data transaction information.

E. Tear off functionality to support multiple monitors:
1. Maximize video viewing area by reducing navigation tabs.
2. Tabbed work environment to quickly switch between multiple work spaces, accessing both live video and recorded tabs with a single click.
3. User-friendly dashboard appears at the bottom of the window for managing various tasks such as system setup, PTZ controls, image adjustments, search criteria and more.

F. Application Features:
1. Logical Cameras and System Groups.
2. Multiple Monitor Support.
3. Quick Review.
4. Quick Sort: by device name, IP address or custom-definition.
5. Tours.
6. PTZ Camera Control.
7. Digital Zoom.
8. Audio Support.
10. Video Authentication.
11. Video Analytics.
12. Right-click Functionality: From secondary navigation or tabbed work area.
13. Tabbed Work Area: Multiple tabs and context-sensitive icons.
14. Any data displayed in any window pane:
   a. Data from third-party devices.
   b. Alarms.
   c. Events.
   d. Active Alert alarm list.
   e. Audio.
   f. RSS feeds.

G. Flexible Integration of Applications:
1. Automated Online Updates - download software updates and patches via the Internet.
2. Video Analytics for viewing and search capabilities.

H. Expand and upgrade existing software manufactured by Axis. Provide necessary licensing and hardware to upgrade existing software to Axis Enterprise software management platform.
2.3 IP NETWORK CAMERA

A. Supplier shall have Owner pre-approval of all camera views prior to final camera position, lens set-up and ordering of mounting hardware. Order lens based on coverage requirements determined in meetings with Owner.

B. Interior / Exterior Fixed IP Camera (Type “C1” – interior camera, Type “C4” exterior). IP Camera to have the following minimum characteristics:
   1. 2-megapixel resolution (1280 x 960).
   2. Progressive scan 1/2.8” CMOS image sensor.
   3. Full color images at .2 lux and monochrome images at .05 lux.
   4. 2.8-10 mm varifocal lens.
   5. Frame rate H:264 compression: 25/30 FPS all resolutions.
   6. Corridor mode
   7. RJ-45 connector.
   8. PoE+ 802.3 at Class 4,
   9. Provide wall, corner, pole, parapet, ceiling mount kit,
   10. H.264 High, Main or Base profiles; and MJPEG compression
   11. dual streaming (two independent IP video streams)
   12. day/night operation with IR cut filter
   13. Wide Dynamic Range (WDR): 130 dB
   14. multicast and unicast capable with unlimited H.264 viewers
   15. local storage via SD/SDHC/SDXC
   16. audio input and output
   17. alarm input and output
   18. Exterior cameras: Environmental Enclosure NEMA 4X, IP66 and IK10
      a. P3224-V Mk II
      b. P3224-LVE
      c. P3245-V Mk II

C. Exterior Fixed IP Cameras (Type "C5): Provide hi-resolution dome day/night cameras for exterior surveillance. IP cameras to have the following minimum characteristics:
   1. 2-megapixel resolution (1920x1080).
   2. Progressive scan 1/2.8” CMOS image sensor.
   3. Full color images at .2 lux and monochrome images at .05 lux.
   4. 3-9mm varifocal lens.
   5. Frame rate H:264 compression: 30 FPS all resolutions.
   6. Corridor mode
   7. RJ-45 10BASE-T/100BASE-TX Terminal block for 1 alarm input and 1 output, 3.5 mm mic/line-in and 3.5mm line-out connector.
   8. PoE+ 802.3 at Class 3, Max 12.1 W
   10. H.264 High, Main or Base profiles; and MJPEG compression
   11. dual streaming (two independent IP video streams)
   12. day/night operation
   13. multicast and unicast capable with unlimited H.264 viewers
   14. local storage via SD/SDHC/SDXC
   15. audio input and output
   16. alarm input and output
   17. Environmental Enclosure NEMA 4X,
   18. IP66 and IK10 impact resistant enclosure

D. Exterior 180° IP Camera. Provide high resolution panoramic fixed dome IP camera for exterior surveillance. IP camera to have the following minimum characteristics:

1. Resolution:
   a. 4x (2048x1536) @ 12.5 frames per second.
2. CMOS Imager: 3x 1/3.2 progressive scan.
3. Minimum Illumination:
   a. Color: .05 lux, F2.5.
   b. B/W: .2 lux, F2.5.
4. Wide Dynamic Range: 120 dB.
5. Lens: (4) fixed focus 5.0 mm, F2.8 combined horizontal angle 180° view.
7. Housing:
   a. IP66 and NEMA 4x rated.
   b. IK10 impact resistant aluminum with polycarbonate cover and dehumidifying membrane.

8. RJ-45 connector.
9. PoE 802.3at Type 2 Class 4 25.5W.
10. H.264 compression.
11. Provide wall, corner, ceiling, pole, parapet mount.

E. Exterior 360° IP Camera Provide high resolution panoramic fixed dome IP camera for outdoor surveillance. IP camera to have the following minimum characteristics:

1. Resolution:
   a. 4x (2048x1536) @ 12.5 frames per second.
2. CMOS Imager: 3x 1/3.2 progressive scan.
3. Minimum Illumination:
   a. Color: .05 lux, F2.5.
   b. B/W: .2 lux, F2.5.
4. Wide Dynamic Range: 120 dB.
5. Lens: (4) fixed focus 5.0 mm, F2.8 combined horizontal angle 180° view.
7. Housing:
   a. IP66 and NEMA 4x rated.
   b. IK10 impact resistant aluminum with polycarbonate cover and dehumidifying membrane.

8. RJ-45 connector.
9. PoE 802.3at Type 2 Class 4 25.5W.
10. H.264 compression.
11. Provide wall, corner, ceiling, pole, parapet mount.
12. Basis of Design: Axis Q3707-PE
13. PTZ Camera:
   a. CMOS Imager 1/2.8° progressive scan.
b. Lens:  4.4 mm – 142.6 mm, F1.6 – 4.41.

c. Day/Night switching with wide dynamic range.

d. Minimum Illumination:

  1) Color: .3 lux.
  2) Monochrome: .03 lux.

e. 32x optical zoom, 12 digital zoom.

f. H.264 compression 25/30 FPS all resolutions.

g. IP66 NEMA 4x housing shared with 360° camera.

h. RJ-45 connector.

i. Basis of Design:

  1) Axis Q3719-PLE (Outdoor)
  2) Axis P5515 (Indoor)

F. Camera Housings and Mounts

2.4 INTERIOR AND EXTERIOR HOUSINGS, DOMES, AND APPLICABLE WALL, CEILING, CORNER, POLE, AND ROOFTOP MOUNTS ASSOCIATED WITH THE HOUSING. HOUSINGS AND MOUNTS SHALL BE SPECIFIED IN ACCORDANCE TO THE TYPE OF CAMERAS USED.

1. All cameras and lenses shall be enclosed in a tamper resistant housing. Any additional mounting hardware required to install the camera housing at its specified location shall be provided along with the housing.

2. The camera and lens contained inside the housing shall be installed on a camera mount. All additional mounting hardware required to install the camera housing at its specified location shall be provided along with the housing.

3. Shall be manufactured in a manner that are capable of supporting a maximum of three (3) cameras with housings, and meet environmental requirements for the geographical area the camera support equipment is being installed on or within.

4. Environmentally Sealed

  a. Provide a condensation free environment for correct camera operation.
  b. Operated in a 100 percent condensing humidity atmosphere.
  c. Shall be constructed in a manner that:
  d. Has a fill valve to allow for the introduction of nitrogen into the housing to eliminate existing atmospheric air and pressurize the housing to create moisture free conditions.
  e. Has an overpressure valve to prevent damage to the housing in the event of over pressurization.
  f. Equipped with a humidity indicator that is visible to the eye to ensure correct atmospheric conditions at all times.
  g. The leak rate of the housing is not to be greater than 13.8kPa or 2 pounds per square inch at sea level within a 90-day period.
  h. Camera mounts or supports as needed to allow for correct positioning of the camera and lens.
  i. The housing and sunshield are to be white in color.
  j. All electrical and signal cables required for correct operations shall be supplied in a hardened carrier system from the controller to the camera.
  k. The mounting bracket shall be adjustable to allow for the housing weight of the camera and the housing unit it is placed in.
  l. Accessibility to the camera and mounts shall be taken into consideration for maintenance and service purposes.
5. Indoor Mounts
   a. Ceiling Mounts:
   b. This enclosure and mount shall be installed in a finished or suspended ceiling.
   c. The enclosure and mount shall be fastened to the finished ceiling, and shall not depend on the ceiling tile grid for complete support.
   d. Suspended ceiling mounts shall be low profile, and shall be suitable for replacement of 610mm x 610mm (2 foot by 2 foot) ceiling tiles.

6. Wall Mounts:
   a. The enclosure shall be installed in manner that it matches the existing décor and placed at a height that it will be unobtrusive, unable to cause personal harm, and prevents tampering and vandalism.
   b. The mount shall contain a manual pan/tilt head that will provide 360 degrees of horizontal and vertical positioning from a horizontal position, and has a locking bar or screw to maintain its fixed position once it has been adjusted.

7. Interior Domes
   a. The interior dome shall be a pendant mount, pole mount, ceiling mount, surface mount, or corner mounted equipment.
   b. The lower portion of the dome that provides camera viewing shall be made of black opaque acrylic and shall have a light attenuation factor of no more than 1 f-stop.
   c. The housing shall be equipped with integral pan/tilt capabilities complete with wiring, wiring harness, connectors, receiver/driver, pan/tilt control system, pre-position cards, or any other hardware and equipment as needed to fully provide a fully functional pan/tilt dome.
   d. The pan/tilt mechanism shall be:
      1) Constructed of heavy duty bearings and hardened steel gears.
      2) Permanently lubricated to ensure smooth and consistent movement of all parts throughout the life of the product.
      3) Equipped with motors that are thermally or impedance protected against overload damage.
      4) Pan movements shall be 360 degrees and tilt movement shall not be less than +/ - 90 degrees.
      5) Pan speed shall be a minimum of 10 degrees per second.

8. Exterior Domes
   a. The exterior dome shall meet all requirements outlined in the interior dome paragraph above.
   b. The housing shall be constructed to be dust and water tight, and fully operational in 100 percent condensing humidity.

9. Exterior Wall Mounts
   a. Shall have an adjustable head for mounting the camera.
   b. Shall be constructed of aluminum, stainless steel, or steel with a corrosion-resistant finish.
   c. The head shall be adjustable for not less than plus and minus 90 degrees of pan, and not less than plus and minus 45 degrees of tilt. If the bracket is to be used in conjunction with a pan/tilt, the bracket shall be supplied without the adjustable mounting head, and shall have a bolt-hole pattern to match the pan/tilt base.
   d. Shall be installed at a height that allows for maximum coverage of the area being monitored.
10. Explosion Proof Housing
   a. This housing shall meet or exceed all requirements of NEMA four (4) standards for hazardous locations.
   b. It shall be supplied with the mounting brackets for the specified camera and lens.

2.5 MISCELLANEOUS COMPONENTS
   A. Power Supplies

2.6 POWER SUPPLIES SHALL BE A LOW-VOLTAGE POWER SUPPLIES MATCHED FOR VOLTAGE AND CURRENT REQUIREMENTS OF CAMERAS AND ACCESSORIES, TYPE AS RECOMMENDED BY CAMERA AND LENS MANUFACTURER.
   A. Input: 115VAC, 50/60Hz, 2.7 amps
   B. Outputs:
      1. Number of outputs, 16.
      2. Fuse protected, power limited
      3. Output voltage & power:
         a. 24VAC @ 12.5 amps (300VA) or 28VAC @ 10 amp (280VA) supply current
      4. Illuminated power disconnect circuit breaker with manual reset
      5. Surge suppression
      6. Camera synchronization
      7. Wall mount.
      8. Enclosure: NEMA 250, Type 1
   C. Infrared Illuminators
      1. Lighting fixtures that emit light only in the infrared spectrum, suitable for use with cameras indicated, for nighttime surveillance, without emitting visible light.
   D. Field-Selectable Beam Patterns: Narrow, medium, and wide.
      1. Rated Lamp Life: More than 8000 hours
      2. Power Supply: 12-VAC/DC.

2.7 AREA COVERAGE: ILLUMINATION TO 50 M (150 FEET) IN A NARROW BEAM PATTERN.
   A. Exterior housings shall be suitable for same environmental conditions as associated camera.
   B. Surge Protection Equipment

2.8 POE SURGE PROTECTION DEVICE
   A. Compatible with Cat 6A twisted pair cabling
      1. PoE + 802.3 af / at compliant
      2. RJ-45 connector and grounding screw
      3. Support up to 10GB transmission speeds with 500mHz bandwidth
      4. Basis of Design: DITEK – DTK-MRJPOE or approved equal

2.9 POWER
   A. Division 26 shall supply all required transformers for all equipment and 120-volt AC power for all required equipment as appropriate.
2.10 CABLE
A. Reference Division 27 “Structured Telecommunications Cabling System” for cabling requirements in this section.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine areas and conditions under which video surveillance systems are to be installed, and notify Architect/Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.2 INSTALLATION OF VIDEO SURVEILLANCE SYSTEMS
A. Install video surveillance systems including components, in accordance with equipment manufacturer's written instructions, in compliance with National Electrical Code, ANSI C2 and with recognized industry practices, to ensure that video surveillance system complies with requirements and serves intended purposes.
B. Provide all necessary connectors, terminators, interconnections, services, and adjustments required for a complete and operable video surveillance system.
C. Install video surveillance equipment properly to avoid causing mechanical stresses, twisting or misalignment of equipment being exerted by clamps, supports, and cabling.
D. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B, and the National Electrical Code.
E. Confirm camera angle of view with Owner for each camera prior to installation. Provide digital photo of area and identify coverage area. Adjust cabling and mounting requirements to accommodate Owner direction.
F. Program system to support features and functionality as required by Owner as determined through layout and design meetings.
G. Upgrade existing video surveillance system to Genetec Cloud Link software to accommodate this facility and associated cameras. Program system to accommodate new devices. Provide required software and associated licenses.
H. Program graphical map utilizing AutoCAD drawings of the building and the site. Identify locations of cameras on map and allow camera icons to be selected to see camera view.
I. For programming purposes refer to the manufacturers requirements for correct system operations. Ensure computers being utilized for system integration meet or exceed the minimum system requirements outlined on the systems software packages.
J. Existing Equipment
   1. Connect to and utilize existing video equipment, video and control signal transmission lines, and devices as outlined in the design package. Video equipment and signal lines that are usable in their original configuration without modification may be reused with approval from Owner / Engineer.
2. Perform a field survey, including testing and inspection of all existing video equipment and signal lines intended to be incorporated into the Video Surveillance System, and furnish a report to the Owner / Engineer as part of the site survey report. For those items considered nonfunctioning, provide (with the report) specification sheets, or written functional requirements to support the findings and correct the deficiency. As part of the report, the Contractor shall include a schedule for connection to all existing equipment.

3. Make written requests and obtain approval prior to disconnecting any signal lines and equipment, and creating equipment downtime. Proceed only after receiving Owner / Engineer approval of these requests. If any device fails after the Contractor has commenced work on that device, signal or control line, the Contractor shall diagnose the failure and perform any necessary corrections to the equipment.

K. Layout and Design Meeting

1. The Contractor shall perform and complete system programming (including all data entry) at an offsite location using the Contractor’s own copy of the VMS software. The Contractor’s copy of the VMS software shall be of the Owners current version. Once system programming has been completed, the Contractor shall deliver the data to the Owner on data entry forms and an approved electronic medium, utilizing data from the contract documents. The completed forms shall be delivered to the Owner for review and approval at least 90 calendar days prior to the scheduled date the Contractor requires it. The Contractor shall not upload system programming until the Owner has provided written approval. The Contractor is responsible for backing up the system prior to uploading new programming data. Additional programming requirements are provided as follows:

a. Programming for the Video Surveillance Server: The contractor shall provide system related programming. The contractor will be responsible for uploading personnel information (e.g., backgrounds, names, access privileges, access schedules, personnel groupings) along with coordinating with Owner for device configurations, standards, and groupings. Include weekly coordination meeting and working with Owner to ensure data uploading is performed without incident of loss of function or data loss.

b. Programming for Existing Servers: Perform system programming. Weekly coordination meeting and working alongside of Owner to ensure data uploading is performed without incident of loss of function or data loss. System programming for Video Surveillance servers shall be performed by using the Contractor’s own server and software. These servers shall not be connected to existing devices or systems at any time.

c. Identify and request from the Owner, any additional data needed to provide a complete and operational system as described in the contract documents.

d. Programming requires a high level of coordination to ensure programming is in accordance with Owner requirements and programming uploads do not disrupt existing systems functionality. At a minimum include the following for review and Owner signoff in coordination meetings with the Owner:

1) Request Owners IP mapping scheme and associate IP addresses required for this project

2) Review camera angles and coverage requirements

   a) Provide snapshot of proposed camera view for both Day and Night. Include IR emitters for night view if cameras support the technology.

   b) Provide snapshot of WDR and associated coverage requirements. Include additional camera technologies that will improve image
3) Review camera live streaming frame rates and resolution with Owner. Adjust as directed by the Owner.  
4) Review Storage requirements with Owner. Adjust compression, resolution and frame rate as directed by the Owner.  
5) Review and establish recording schedule and any associated uploading of video to centralized storage system.  
6) Review IR settings and associated image adjustments. Adjust as directed by the Owner.  
7) Review motion detection / analytics / tamper settings available to cameras and VMS with owner. Adjust settings as directed by the Owner.  
8) Review and establish privacy zone requirements as directed by the Owner  
9) Review PTZ tour / presets. Configure as directed by Owner.  
10) Enable / Disable audio if functionality is available with camera as directed by the Owner.  
11) Review camera title / names with time date / overlay. Adjust as directed by Owner  
   a) Review and apply Owners labeling scheme for cameras and associated cabling  
12) Verify and implement NTP server in accordance with the Owners requirements  
13) Review event / alarms and develop response list associated with alarms.  

2. Document programming direction obtained from the Layout and Design meetings for signoff by Owner / Engineer prior to implementing.  

3.3 CABBING INSTALLATION REQUIREMENTS  
A. All cabling shall be fully concealed in the facility. All cabling shall be run in conduit, surface raceway or installed above accessible ceilings in cable tray where applicable.  

3.4 SYSTEM TESTING, ADJUSTMENTS, AND CLEANING  
A. Upon completion of work, and prior to final system testing has begun, all system equipment shall be cleaned of all construction dust and debris.  
B. Upon completion of the system installation, and after circuitry has been energized with the normal power source, the manufacturer/supplier shall test the system to verify the following:  

3.5 ALL COMPONENTS ARE OPERATIONAL AND FUNCTIONING PROPERLY TO THE SYSTEM DESIGNS INTENT.  
A. The complete system is free from grounds, open and shorts except for made grounds required by the system installation.  
B. Correct all of the above and retest to demonstrate compliance where required by Engineer.  
C. Provide in writing, a report containing results of all tests and certification that the video surveillance system installation is completed to begin performance verification testing. Include in the report approved performance verification test procedures. Provide a video recording showing typical day and night views of each camera in the system on DVD with the report.  
   1. Documentation any objects in the field of view that might produce highlights that could cause camera blinding.  
   2. Point out any objects in the field of view which may cause blind spots. Depict if a camera cannot be aimed to cover the zone and exclude the rising or setting sun from the picture.  

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3. Recording shall provide night assessment capabilities and whether lights or vehicle headlights cause blooming or picture degradation.
4. If any of the above conditions or other conditions are present that cause picture degradation or interfere with the camera field of view, the Contractor shall inform the Engineer.
5. The DVD shall be recorded using the video recorder installed as part of the Video Surveillance system. The Contractor shall provide the engineer with the original DVD as part of the documentation of the system and shall submit a letter signed by an officer of the company certifying that the Video Surveillance system is ready for performance verification testing.

D. Include the following field testing and document:
1. Cameras:
   a. Physical Installation:
      1) Tighten housing and mount fasteners and screws
      2) Weatherproof outdoors mounts are installed to manufacturers specifications
      3) Clean lens, dome and housing glass surfaces
      4) label cameras
   b. Camera View Setup
      1) Aim and focus cameras and review angles with Owner.
      2) Save day / full light snapshot and submit with closeout documentation
      3) Save night snapshot and submit with closeout documentation
      4) Obtain signoff the day / night views meet Owner requirements
      5) Obtain signoff from Owner that WDR views meet Owner requirements
      6) When pan/tilt mounts are used in the system, verification that the limit stops have been set correctly. Verification of all controls for pan/tilt or zoom mechanisms are operative and that the controls perform the desired function. If preposition controls are used, verification that all home positions have been set correctly, and have been tested for auto home function and correct home position.
      7) When dome camera mounts are used in the system, verify that all preset positions are correct and that the dome also operates correctly in a manual control mode.
      8) If vehicles are used in proximity of the assessment areas, verification of night assessment capabilities and determination if headlights cause blooming or picture degradation.
      9) Verification that all cameras are aimed and focused properly. The Contractor shall conduct a walk test of the area covered by each camera to verify the field of view.
      10) Verification that cameras facing the direction of rising or setting sun are aimed sufficiently below the horizon so that the camera does not view the sun directly.
   c. Verification that all cameras are synchronized and that the picture does not roll when cameras are switched.
   d. Verification that the alarm interface to the access control is functional and that automatic camera call-up is functional with appropriate video annotation for all designated alarm points and cameras.
   e. Network / Security settings
      1) Document MAC addresses
2) Implement Owners IP mapping scheme and document IP addresses provided by the Owner
3) Update firmware to the latest version available
4) Change administration passwords from default
5) Set NTP server and verify time and date are consistent with Owner’s network.
6) Disable unused services / close unused ports (FTP, Telnet, SSH, etc.)
7) Configure IP cameras that are accessible to different users.

f. Configuration changes:
   1) Set camera resolution to maximum provided by camera unless directed otherwise and document change
   2) Set framerate to maximum provided by camera unless directed otherwise and document
   3) Verify recorded video resolution and frame rate meet specifications.
   4) Configure compression settings as recommended by the manufacturer.
   5) Configure WDR and additional image improvement technologies offered by camera manufacturer and NVR manufacturer.
   6) Configure exposure, adjust shutter to improve image quality
   7) Configure integrated IR power, range, and smart IR settings if present.
   8) Configure video motion detection / analytics / tampering settings
   9) Configure privacy zones as directed by Owner
  10) Configure Audio as directed by Owner
  11) Configure camera title and time / date overlay as directed by Owner
  12) Configure event notifications (email / text, etc…)
  13) Download and turnover electronic copy of camera configuration as part of Closeout documentation

2. Video Management Software / Network Video Recorder
   a. Hardware / Security
      1) Document MAC Addresses
      2) Implement Owners IP mapping scheme and document IP addresses provided by the Owner
      3) Apply latest OS updates as recommended by manufacturer
      4) Create secure Administration password
      5) Create additional users as requested by Owner
      6) Test operation of UPS if provided
   b. General Settings
      1) Update software / recorders to the latest version
      2) Set NTP server and verify time and date are consistent with Owner’s network.
      3) Disable unused services / close unused ports (FTP, Telnet, SSH, etc.)
      4) Configure storage volumes (physical drives, NAS, SAN, SATA, etc…)
      5) Configure recording schedule, length, motion cameras, etc…
   c. Download and turnover VMS configuration as part of closeout documentation

3. Workstations / Security Monitors
   a. Document MAC Addresses
   b. Implement Owners IP mapping scheme and document IP addresses provided by the Owner
   c. Apply latest OS updates as recommended by manufacturer
   d. Create secure Administration password
e. Install VMS client and update to latest version
f. Configure camera views as required
g. Configure camera tours / switching as directed by the Owner
h. Configure map views as directed by the Owner
i. Configure event / alarm lists as directed by Owner
j. Test operation of UPS if provided

4. Cabling:
   a. Label cables, patch panels, outlets, cameras, ceilings, etc.
   b. Ensure cables are secured to supports
   c. Conceal where exposed
d. Provide coiled and dressed service loops at camera locations and in data rack / headend.
e. Test all terminations and document results.
   f. Verification that the video transmission system and any signal or control cabling have been installed, tested, and approved as specified.
g. Verification that all video signals are terminated properly.
h. When the system includes remote control/monitoring stations or remote switch panels, verification that the remote devices are functional, communicate with the security center, and perform all functions as specified.
i. Verification that all video sources and video outputs provide a full bandwidth signal that complies with CEA 170 at all video inputs.

E. The manufacturer/supplier shall set all field adjustable components to optimize the system.
   Balance all signals, adjust and verify input voltages, current settings and frequency settings.

3.6 TRAINING

A. Provide on-site training on the use of the video distribution system to the Owner’s selected personnel.
   1. Provide a minimum of 16 hours of training to selected personnel for the operation, maintenance, and replacement of equipment and controls.

3.7 OPERATION AND MAINTENANCE MANUALS

A. Equipment Manuals:
   1. Provide a complete set of equipment cut sheets, parts list including maintenance criteria "troubleshooting" guide, distributor information and service information for all equipment provided.
   2. Provide a complete set of instruction manuals, including complete written operating instructions, programming documentation and system set-up documentation.
   3. Provide all test results performed.

B. Equipment Drawings:
   1. Contractor shall provide a revised set of system wiring diagrams upon the completion of the installation for subsequent testing of the system to show actual cable routing of all equipment as installed.
      a. Utilize architectural floor plans for system layout.
3.8 DEMONSTRATION
A. Upon completion of installation of video surveillance components, and after circuitry has been energized with normal power source, test video surveillance systems to demonstrate capability and compliance with requirements with Owner. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance, otherwise remove and replace with new units and proceed with retesting.
B. Provide in-service training to customer on system operation, basic design principles and capabilities.
C. Provide customer with operation/maintenance procedure manuals for each piece of equipment.
D. Submit to customer a recommended PM (Preventative Maintenance) procedure including schedules, recommended space parts list and cleaning procedures.

3.9 VIDEO SURVEILLANCE SYSTEM INSTALLATION
A. Install cameras and infrared illuminators level and plumb.
B. Install cameras with 84-inch minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.
C. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms, and adjust.
D. Install power supplies and other auxiliary components at control stations, unless otherwise indicated.
E. Customize camera labeling system as directed by Owner to simplify recognition of camera location.

3.10 FIELD QUALITY CONTROL
A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation and supervise pretesting, testing, and adjusting of video surveillance equipment.
B. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
C. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video surveillance equipment for acceptance and operational testing as follows:
   1. Prepare equipment list described in Part 1 "Submittals" Article.
   2. Verify operation of auto-iris lenses.
   3. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
   4. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet (17 to 23 m) away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
   5. Set and name all preset positions; consult Owner's personnel.
7. Connect and verify responses to alarms.
8. Verify operation of control-station equipment.

D. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule. Schedule exterior camera tests for range of lighting conditions including night.

E. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.

F. Remove and replace malfunctioning items and retest as specified above.

G. Record test results for each piece of equipment.

H. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

3.11 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions and to optimize performance of the installed equipment. Tasks shall include, but are not limited to, the following:
   1. Check cable connections.
   2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
   3. Adjust all preset positions; consult Owner's personnel.
   4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's utilization of video surveillance system.
   5. Provide a written report of adjustments and recommendations.

3.12 CLEANING

A. Clean installed items using methods and materials recommended in writing by manufacturer.

B. Clean video surveillance system components, including camera-housing windows, lenses, and monitor screens.

END OF SECTION 282300
SECTION 283100 – FIRE ALARM SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes an extension of the existing fire alarm system into the renovation and new addition areas.
B. Related Sections include the following:
   1. Division 08 Section "Door Hardware" for door closers and holders with associated smoke detectors, electric door locks, and release devices that interface with the fire alarm system.
   2. Division 21 Section "Fire Protection" for waterflow and tamper switches, alarm check valves, and fire pump devices that interface with the fire alarm system.
   3. Division 26 Sections for components and methods of the fire alarm system installation.

1.2 DEFINITIONS
A. ADS: Acoustically Distinguishable Spaces – a notification appliance(s) zone distinguishable from other spaces because of different acoustical, environmental, or use characteristics.
B. BAS: Building Automation System.
C. CIS: Common Intelligibility Scale.
D. ECC: Emergency Communication Center – dedicated building emergency command room.
E. ECCU: Emergency Communications Control Unit for fire alarm and mass notification system, voice communications system functions.
F. FACU: Fire Alarm Control Unit.
G. FATC: Fire Alarm Terminal Cabinet.
H. FCVC: Fire Alarm Campus Voice Command Center.
J. FPU: Field Processing Unit.
K. LCD: Liquid Crystal Display.
L. LED: Light-Emitting Diode.
M. MNS: Mass Notification System.
N. NAC: Notification Appliance Circuit.
P. UPS: Uninterruptible Power Supply.
Q. Definitions in NFPA 72 apply to fire alarm terms used in this Section.
1.3 COORDINATION

A. Recommend to owner and request approval of nameplate inscriptions, zone designations, and system designations on system annunciators and central control equipment prior to shop drawing submittals.

B. Coordinate together with equipment suppliers and other Divisions, their equipment operational voltages and controls for proper system operation and interface requirements. Provide any necessary auxiliary equipment and software for system interfaces. The auxiliary equipment shall provide for, but not be limited to:

1. Division 23 smoke control and fan shutdown interfaces.
2. Interface(s) to existing fire alarm system.
3. NAC extender panel(s) interfaces.
4. Electro-magnetic door holder release interfaces.
5. Security system door release interfaces.
6. Rolling counter door power and interfaces.
7. 120 volt power connections.
8. Exact duct detector locations and quantities at air handling equipment and in HVAC ductwork.
9. Exact water flow and tamper switch locations and quantities in fire protection system.
10. Non-system detectors and addressable relay interfaces.
11. Wire guards per Section Division 26 Section "Wiring Devices."
12. Telecommunications dedicated fiber optic backbone cabling interfaces for FCCC to FACU communications.
13. Breaker handle clips and signage at panelboards servicing fire alarm devices.

C. Nameplates shall be per Division 26 Section "Electrical Identification."

D. All information for the system wiring shall be supplied by the manufacturer. The sizes of the different wires shall be those specified by the manufacturer. Building wire shall be in accordance with Division 26 Section "Low Voltage Electrical Power Conductors and Cables" and NEC articles 760, 775, and 800.

E. Coordinate exact duct detector locations at air handling units and in return and exhaust HVAC ductwork.

1.4 SEQUENCING AND SCHEDULING

A. Existing Fire Alarm Equipment: Maintain fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire alarm equipment "NOT IN SERVICE" until removed from the building.

B. Equipment Removal: After acceptance of the new fire alarm system, remove existing disconnected fire alarm equipment.

C. Interruption of Existing Fire Alarm Service: Do not interrupt fire alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:

1. Notify Construction Manager and Owner no fewer than seven 7 days in advance of proposed interruption of fire alarm service.
2. Do not proceed with interruption of fire alarm service without Construction Manager's or Owner's written permission.
1.5 SUBMITTALS

A. General: Submit the following in accordance with Division 28 Section "Basic Division 28 Requirements."

1.6 ACTION SUBMITTALS

A. Submittals to Authorities Having Jurisdiction: In addition to distribution requirements for submittals specified in Division 01 Section "Submittals," make an identical submittal to authorities having jurisdiction. To facilitate review, include copies of annotated Contract Drawings as needed to depict component locations. Resubmit if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Architect for review.

B. Equipment Shop Drawing Submittal:

1. Supplier qualifications.
2. Provide complete catalog cuts and specification sheets, ITEMIZED BY CONTRACT DRAWING SYMBOL, for all components to be installed as well as a general system operation description and control-by-event schedule. The submittal shall clearly depict UL listing and FM approval of system and components. The system operation description shall include the method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs. Description shall be applicable to this project. Manufacturer's standard descriptions for generic systems are not acceptable.
3. Provide itemized description/comparison of where and how equipment and operational items specified are accomplished if different than specified but meet the functional intent.
4. Provide scaled drawings for all terminal cabinets, panels and amplifiers. Submit complete coordination drawings depicting equipment and showing all major component sizes and locations at 1/4 inch scale minimum per Division 28 Section "Basic Division 28 Requirements."
5. Provide spare parts listing.
6. Provide individual amplifier power supply, and FPU point size calculations indicating spare capacity.
7. Provide calculations for battery capacity for both alarm and supervisory modes.
8. Provide voltage drop calculations for typical Class A (and Class B) circuits and wire sizes identifying maximum length to limit voltage drop to 10 percent maximum.
9. Equipment quantities (for record only).
10. Original equipment manufacturer warranty statement.

C. Pre-Installation Shop Drawing Submittal:

1. Submit two full sets of shop drawings drawn specifically for the project, one set of associated reproducible shop drawings, five full sets of data sheets, and installation manuals instructions detailing the manufacturer's recommendations for all equipment installations.
3. Floor plan drawings showing:
   a. Locations of all fire detection, alarm, and notification system devices, equipment, risers and electrical power connections including unique addressing of each addressable device and circuit.
1) Provide indicated and additional device location(s) based upon manufacturers recommendations if coverage or sensitively is less than code required expectations based on Contract Drawings. Be responsible to verify with local authorities as appropriate. Supply such additional devices at no cost to Owner.

b. Minimum expected notification appliance(s) dBA value for each room in the project scope when local appliance tap setting(s) are set at a lower (1/2 or 1 watt) of range; and expected average/maximum ambient dBA values for that room. This shall indicate audible level compliances.

c. Minimum expected notification appliance(s) CIS value for each room in the project scope when local application tap setting(s) are set at a lower (1/2 or 1 watt) of range; and expected average/maximum CIS values for that room. This shall indicate voice intelligibility level compliances and in conjunction with specific ADS zone requirements.

d. Routing, number, size and type of conductors; expected voltage drop, and conduit size and fill percentage.

e. Terminal-to-terminal wiring connections showing all individual circuits and circuit/conduit routing.

f. Conduit fill calculations indicating the cross section area percent fill for each type of wire/cable in each size of conduit used in the system.

g. Conduit routing and proposed height and method of coring.

h. System zoning including color coded floor plans showing both system input and output zones.

4. Detailed point to point wiring diagrams specific to the project for all alarm control panels, control panel modules, power supplies, electrical power connections, auxiliary function relays and remote annunciation equipment. Detail wiring diagrams shall show and identify all terminations, including terminal identifications, size and type of conductors.

a. These diagrams shall depict and identify all circuit boards, modules, power supplies, dip switches, jumpers, leds, indicators, adjustable controls or components, ribbon connectors, wiring harnesses, terminal strips and connections thereto, including spare zones or circuits.

b. Diagrams required by this section shall depict the required information as to relative scale, actual size, or larger, showing proper spacial relationships between components.

5. A system riser diagram or diagrams showing:

a. Number and size of riser conduits.

b. Number, size, type and function of conductors in each riser.

c. The number of each type of device on each floor and zone.

6. Each floor plan drawing, typical wiring diagram, detailed wiring diagram and system riser diagram shall be cross-referenced to all related drawings. It is intended that the complete submittal shall include all information necessary for system installation.

7. Device address list.

8. Each drawing will show the revision number and date in the title block.

9. Installer certifications and licensing.

10. Factory training information.

1.7 INFORMATIONAL SUBMITTALS

1. Field and quality control test reports.
1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Manual Submittal:

1. Provide operation and maintenance data for inclusion in Operation and Maintenance Manual specified in Division 01 and in Section "Basic Division 28 Requirements." Operation and maintenance data shall cover each type of product, including all features and operating sequences, both automatic and manual. Provide the name, addresses, and telephone numbers of service organizations that carry stock of repair parts for the system to be furnished.

2. Upon completion of the project, submit three copies of operation and maintenance manual, bound in a three-ring binder, containing:
   a. A detailed narrative description of the system architecture, inputs, evacuation signaling, auxiliary functions, annunciation, intended sequence of operation, expansion capability, application considerations and limitations.
   b. A detailed description of routine maintenance required or recommended, or as would be provided under a maintenance contract, including a maintenance schedule and detailed maintenance instructions for each type of device installed.
   c. An equipment list/schedule detailing all equipment and quantities installed. The manufacturer's product model/identification number shall be shown next to each piece of equipment on the list.
   d. Manufacturer's data sheets and installation manuals/instructions for all equipment installed.
   e. A list of provided and recommended spare parts and accessories which the manufacturer recommends be stocked for maintenance of the system.
   f. A detailed description of the operation of the systems, including operator responses. Copies of the approved sequence of operation shall be placed in, or adjacent to, the FACU and maintenance office as directed by Owner.
   g. Power supply and standby battery load calculations for each power supply in the system. Included with these calculations, a list shall be provided detailing the type, quantity and normal and alarm current for each type of device installed in the system.
   h. Audio and visual load calculations for each notification application circuit, power supply and amplifier indicating spare capacity allowances in the system.
   i. A complete riser diagram and 8-1/2 x 11-inch plasticized copies of all detailed wiring diagrams and control panel wiring diagrams, as approved for the contractor's record drawing submittal.
   j. Complete software documentation and programming instructions.
   k. Submit 6 extra sets of software user manuals.
   l. Compact disk(s) of final approved shop drawings and operation and maintenance submittals.
   m. Other requirements, defined by NFPA 72, Appendix A.

B. Complete Buildings As-Builts: Coordinate through the Construction Manager a complete set of as-built drawings for filing at the FACU for firefighter's use.

C. Miscellaneous Submittals: Submittals for system certification, testing, and record drawings shall be per Division 01 and associated Part 3 article of Division 28 Section "Fire Alarm Systems."

D. Documentation:

1. Approval and Acceptance: Provide the "Record of Completion" form according to NFPA 72 to Owner, Engineer, and authorities having jurisdiction.
2. Record of Completion Documents: Provide the "Permanent Records" according to NFPA 72 to Owner, Engineer, and authorities having jurisdiction. Format of the written sequence of operation shall be the optional input/output matrix.
   a. Hard copies on paper to Owner (3), Engineer (1), and authorities having jurisdiction (1).
   b. Provide hard copy at fire command center. Install in FATC cabinet used exclusively for these files.

1.9 SPARE PARTS
A. General: Unless directed otherwise by owner, furnish spare part of matching products installed, as described below, and as recommended by the manufacturer, packaged with protective covering for storage, and identified with labels clearly describing contents.
   1. Two compact disk and hardcopy sets of all system software and graphics.
   2. Lamps for Remote Indicating Lamp Units: Furnish quantity equal to 5 percent of the number of units installed, but not less than six.
   3. Lamps for Strobe Units: Furnish quantity equal to 10 percent of the number of units installed.
   5. Detector Bases: Furnish quantity equal to 2 percent of the number of units of each type installed.
   6. Notification Appliances: Furnish quantity equal to 10 percent of number of units of each type installed.
   7. Six spare fuses for each fused circuit in the system.
   8. Six sets of any special tools required.
   9. Twelve spare screws of each type installed.
   10. Six screwdrivers of each type needed for system repairs/maintenance.
   11. Keys and locks for all equipment shall be identified and identical where possible. Not less than 12 keys for each type required shall be provided. Key numbering chart shall be provided in each instruction manual furnished.

B. Allowance: Furnish labor and material to install five smoke detectors and five notification devices to meet unknown final AHJ requirements. Include all raceway and cable for a fifty foot homerun from each device and all incidentals per the requirements of this Section, including circuit tie-ins and reprogramming.

1.10 MAINTENANCE SERVICES
A. Maintenance Service Contract: Provide free maintenance of fire alarm systems and equipment for the duration of the original equipment manufacturers warranty period (minimum one year) commencing with Substantial Completion, using factory-authorized service representatives.

B. Basic services: Systematic, routine maintenance visits on a monthly basis at times coordinated with the facility. In addition, respond to service calls within 24 hours of notification of system trouble. Adjust and replace defective parts and components with original manufacturer's replacement parts, components, and supplies. Include option of automatic yearly or individual software enhancement prices.
C. Additional Services: Perform services within the above warranty period not classified as routine maintenance or as warranty work as described in Division 01 Section “Warranties” when authorized in writing. Compensation for additional services must be agreed upon in writing prior to performing services.

D. Renewal of Maintenance Service Contract: No later than 60 days prior to the expiration of the maintenance services contract, deliver to Owner a proposal to provide contract maintenance and repair services for an additional one-year term. Owner will be under no obligation to accept maintenance service contract renewal proposal.

1.11 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer who is a factory-authorized service representative and licensed to perform the Work of this Section.

1. The equipment manufacturer shall have a local branch office with engineering and service departments staffed with trained, full time employees capable of testing, inspection, repair and maintenance services for the life of the fire alarm system.

2. The equipment supplier shall make available to the Owner, the services of an authorized representative of the manufacturer to train facility maintenance personnel in the operation, programming and routine maintenance of the system.

3. The equipment supplier shall represent a major fire alarm equipment manufacturer and shall conform to and provide proof of the following:
   a. Has represented the equipment manufacturer for a minimum of three years in the project area.
   b. Has a local shop with all testing equipment and a complete local stock of replacement parts and materials for servicing the equipment supplied.
   c. Has 24-hour emergency service for servicing equipment after normal working hours.
   d. Has suitable finances to provide the work indicated, the guarantee required, and to provide future service on the equipment under contract or on-call basis.
   e. Has trained, full time employees to provide necessary testing, inspection, repair and maintenance of the system. The service technicians must be certified by the project State’s Department of Labor as Fire Alarm Journeymen Mechanics. National Institute for Certification in Engineering Technologies (NICET) level III certification shall be considered equal. A copy of NICET level III certification or state certification shall be submitted to the engineer with pre-installation shop drawing submittal.

1.12 COMPATIBILITY

A. All new fire alarm systems and their associated components shall be of the same manufacturer's product line, to match existing equipment, except for special sub-systems or non-system detectors monitored by the main system.

B. It shall be the responsibility of the contractor to perform a load survey to determine field measured values of end of line voltage and current draws for any existing notification appliance circuits that are extended or altered.

C. All key switches and lockable devices shall be keyed alike whenever possible.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. FACU and Equipment, proprietary to match existing equipment:
   a. Honeywell/Notifier (Or match existing system if not Honeywell/Notifier)

2. Wire and Cable:
   a. Belden
   b. Comtran Corporation.
   c. Helix/HiTemp Cables, Inc.; a Draka USA Company.
   d. Rockbestos-Suprenant Cable Corporation; a Marmon Group Company.
   e. West Penn Wire/CDT; a division of Cable Design Technologies.
   f. Radix.

2.2 EXISTING FIRE ALARM SYSTEM

A. Compatibility with Existing Equipment: Fire alarm system and components shall operate as an extension of an existing system. All new equipment shall match existing to whatever extent practical to ensure compatibility, supervision and functionality.

2.3 REGULATORY REQUIREMENTS

A. Compliance with Local Requirements: Comply with the applicable building code, local ordinances, and regulations and the requirements of the authority having jurisdiction.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. ANSI Compliance: Provide a fire alarm and detection system conforming to ASME A17.1.

D. NFPA Compliance: Provide a fire alarm and detection system conforming to the requirements of the following publications:
   2. NFPA 70 - "National Electrical Code."
      a. NEC Article 725 - Class 1, 2 and 3 Signaling Circuits.
      b. NEC Article 760 - Fire Protective Signaling Systems.
   5. NFPA 92A - Smoke Control Systems.

E. The fire system installation company shall be licensed by the Project State to install fire alarm systems. A copy of the State fire alarm install license shall be submitted to the engineer with shop drawing submittal.

F. UL Listing and Labeling: Provide system and components specified in this Section that are listed and labeled by UL and specific references as follows:
   1. UL 38 - Manually Actuated Signaling Boxes.
   2. UL 217 - Smoke Detectors, Single and Multiple Station.
   5. UL 268A - Smoke Detectors for Duct Applications.
   7. UL 464 - Audible Signaling Appliances.
10. UL 1480 - Speakers for Fire Protective Signaling Systems.
13. UL 1638 - Visual Signaling Appliances.
14. The fire system shall comply with local building codes, and meet all requirements of the local authorities having jurisdiction. The complete fire alarm system installation shall be listed by Underwriters Laboratories, Inc. (U.L.) standard UUJS. All components of the fire system shall be U.L. listed.

G. Factory Mutual (FM) Compliance: Provide fire alarm systems and components that are FM approved proprietary signaling systems.


I. Americans with Disabilities Act (ADA) - Latest Edition: Comply with all related fire alarm installation and operating requirements in the Federal ADA law and local accessibility codes.

2.4 SYSTEM DESCRIPTION

A. Noncoded, addressable system; multiplexed signal transmission dedicated to fire alarm service only.
   1. Interface with existing fire alarm system.

B. Smoke/Fire Zones:
   1. Each floor shall be group zoned according to the smoke partition construction, with further breakdown as to the device type. Refer to Drawings for complete description of designated fire alarm zones. Additional zones shall be dedicated but not limited to:
      a. Individual Air Handling Units.
      b. Non-System Detectors.
      c. System detectors zoned per smoke compartment.
      d. Pre-Action Fire Suppression Systems.

2.5 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 72 and local requirements.

B. All fire alarm supervisory, and trouble system signals shall initiate the following actions:
   1. Identify signal condition type at the FACU, FPU’s and ECC, and remote annunciator. Menuing shall allow further signal information such as location, type of device and device address.
   2. Record events in the system memory.
   3. Cause the device in alarm LED indicator to flash.

C. Fire alarm signal initiation shall be by one or more of the following devices:
   2. Heat detectors.
   3. Smoke detectors.
   4. Automatic sprinkler system water flow.
   5. Fire extinguishing system operation.
   6. Fire standpipe system.
   7. Duct Smoke detector (where permitted by the AHJ)
D. Fire alarm signal shall initiate the following additional actions:
   1. Alarm notification appliances shall operate continuously in synchronization.
   2. Transmit an alarm signal to the remote alarm receiving station.
   3. Unlock electric door locks in designated egress paths.
   4. Release fire and smoke doors held open by magnetic door holders.
   5. Activate emergency communications control unit (ECCU).
   6. Stop supply and return fans per sequence of operation noted on the drawings.
   7. Signal the Division 23 base building BAS System of a system alarm such that the BAS intelligence can provide proper smoke and damper control. All associated signals and monitor point contacts shall be coordinated with the BAS subcontractor to provide BAS terminations. This Division 28 function is as follows:
      a. Signal the Division 23 base building BAS System of an alarm in the building.
      b. Signal the Division 23 base building BAS System of an RTU or AHU unit supply or return duct detector alarm such that the base building BAS intelligence can provide proper smoke control.
      c. Shut down fans with controller fire alarm control modules (symbol FR) as shown on Drawings.
   8. Activation of local detectors associated with the following devices shall cause these devices to operate.
      a. Rolling counter doors.
      b. Electro-magnetic door hold release.
      c. Power operated door release.
   9. Record events in the system memory.

E. Supervisory signal initiation shall be by one or more of the following devices or actions:
   1. Operation of a fire-protection system valve tamper switch.
   2. Low-air pressure switch operation on dry pipe or preaction sprinkler system.
   3. Non-system detector alarm contact signal.

F. System trouble signal initiation shall be by one or more of the following devices or actions:
   1. Open circuits, shorts and grounds of wiring for initiating device, signaling line, and notification-appliance circuits.
   2. Opening, tampering, or removal of central control equipment, alarm initiating, and supervisory signal initiating devices.
   3. Loss of primary power at the FACU.
   4. Ground or a single break in FACU internal circuits.
   5. Abnormal ac voltage at the FACU.
   6. A break in standby battery circuitry.
   7. Failure of battery charging.
   8. Abnormal position of any switch at the FACU or annunciator.
   9. Loss of connection to remote alarm receiving station.

G. System Trouble and Supervisory Signal Actions: Ring trouble sounder and annunciate at the FACU, FPU’s and ECCC and remote annunciators. Record the event on system printer.

H. Bypass Control “Drill” Switches:
   1. Activation of SEPARATE auxiliary bypass control switches shall override the automatic functions selectively within the system for:
      a. Transmission of fire alarm condition signal to the remote alarm receiving station
b. Operation of audible alarms (but not affecting indicating alarms).
c. Operation of fire alarm visual alarms.
d. Operation of door release devices.
e. Automatic shutdown of HVAC equipment.
f. Automatic control of smoke dampers.

2. Bypass control shall be overridden upon the activation of a subsequent alarm from another alarmed zone.

2.6 FPU

A. General Description:

1. Field processing unit is a remote network (extender) panel to FACU with identical requirements and centralized acknowledgements, drill switches and system resets required only at FACU.

2. The FPU(s) and FACU networked with each other to interface initiation and indicating functions as a peer-to-peer, token ring topology, network connected with a physically separated loop.

B. FPU shall be microprocessor-based, housed in an all metal cabinet suitable for wall mounting, either flush or surface. Basic FPU size shall be sized to accommodate zoning and control functions as shown on fire alarm riser diagram plus a minimum of 25% spare capacity. Each FPU’s microprocessor, memory, and associated circuitry shall have the ability to detect losses of communications with the FACU, resulting from defects in the communications circuit wiring.

C. Sensing circuits from the FPU to peripheral devices shall be supervised to provide an indication of sensing circuit faults. Sensing circuit supervision shall not reduce available system monitor points. Sensing, circuits shall be capable of reporting an alarm, grounds, shorts, opens or trouble conditions. FPU sensing circuits shall be capable of working with normally open (N/C), or current limited normally open contacts, for Class A wiring and operation.

D. FPU shall be equipped with an internal 24 VDC power supply and shall function as a completely independent system in event of a communications-line break with the FACU or a FACU failure. In the event of a communications or FACU failure, the local FPU shall receive and process monitor point inputs and shall initiate the appropriate control point actions. The local fire alarm annunciator shall function normally for all local zones.

   1. If FPU to FACU communications failure, the FPU shall initiate audible alarms through its own redundant tone generators. The tone generators shall be sized for minimum 25 percent spare capacity above the sum of all devices at maximum tap settings.

   2. Voice/Tone speaker circuits shall have central redundant preamplifiers, amplifiers, and pre-recorded messaging and tone generators, located at the FACU, zoned through distributed amplifiers with addressable outputs at the FPU.

E. Other Control Features/Functions Include:

   1. Interface alarm inputs and control circuits outputs and communicate changes in operating status to the FACU.

   2. Communication between the FPU’s and the FACU shall incorporate a BacNet Local Operating Network (LON) for easy wiring.

   3. The LON shall provide the interface for the Network Input/Output Nodes. The LON shall be a transformer isolated twisted pair network operating a 78.5K baud. Without any additional power boosters the LON shall be capable of wiring runs up to 2000 meters in length. Wiring runs in excess of 2000 meters shall be accomplished with the use of signal boosters.
4. Provide continuous supervision of alarm input circuits and report alarm, opens or ground conditions.
5. The FPU shall operate at 120V AC input with sufficient capacity to operate all alarm inputs and control circuit outputs. The FPU shall be provided with 25 percent spare capacity points.
6. Batteries shall provide operating power to comply with NFPA 72. Batteries and charging circuitry shall be monitored and alarmed for battery failure (low charge or disconnected) or battery charger failure (high charge or system voltage failure).
7. FPU modules shall be card rack mounted, easily expanded, and contain sufficient capacity for all input and output functions as shown on Drawings.
8. Control circuit output relays shall be multiple, convertible contacts, 24V DC, 5A rating. Outputs shall be provided and coordinated for door release, HVAC shutdown, smoke dampers and auxiliary devices as shown on Drawings.
9. The FPU panel shall be interfaced with remote annunciator and FACU.

2.7 FATC
A. Fire alarm terminal cabinets, as required, shall be surface mounted, labeled with "FIRE ALARM" nameplate, and shall contain screw type terminal strips as required for the wiring of the system as shown on Drawings. Provide cabinet size for amount of terminations and equipment modules required, including 10% spare capacity flush or surface mounted as shown on Drawings.
1. Provide lockable FATC cabinet at ECC location for final as-built documents.

2.8 MANUAL PULL STATIONS
A. Description: UL 38 listed; finished in red with molded, raised-letter operating instructions in contrasting color. Station shall show visible indication of operation. Mount on recessed outlet box; if shown on Drawings as surface mounted, provide manufacturer's surface back box.
1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type. With integral addressable module, arranged to communicate manual-station status (normal, alarm, or trouble) to the FACU.
2. Station Reset: Key- or wrench-operated switch.
3. Indoor Protective Shield: When shown on Drawings, provide factory-fabricated clear plastic enclosure, hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
4. Weatherproof Protective Shield: When shown on Drawings, provide factory-fabricated clear plastic enclosure, hinged at the top to permit lifting for access to initiate an alarm. Weatherproof devices shall be non-addressable and rated for the intended equipment; monitored by an addressable module located in a conditioned space.

2.9 SYSTEM SMOKE DETECTORS
A. General Description:
1. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACU.
2. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
3. Remote Control: Detectors shall be analog-addressable type, individually monitored at the FACU for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACU.
   a. Provide multiple levels of detection sensitivity for each sensor.

B. Photoelectric Smoke Detectors:
   1. Sensor: LED or infrared light source with matching silicon-cell receiver.
   2. Back-up Sensor: Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at the FACU to operate at 135 or 155 deg F (68 deg C) deg F (57 deg C).
   3. Detector Photoelectric Sensitivity: Between 0.2 and 3.5 percent/foot (0.008 and 0.011 percent/mm) smoke obscuration when tested according to UL 268A.
   4. UL 268A listed, operating at 24-V dc, nominal.
   5. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection of building wiring.
   6. Local sonalert base audible alarm type as shown on Drawings containing the following:
      a. Piezoelectric sounder rated at 88 dBA at 10 feet (3 m) according to UL 464.

C. Duct Smoke Detector:
   1. Photoelectric Smoke Detectors:
      a. Sensor: LED or infrared light source with matching silicon-cell receiver.
      b. Detector Sensitivity: Between 0.2 and 3.5 percent/foot (0.008 and 0.011 percent/mm) smoke obscuration when tested according to UL 268A.
      c. UL 268A listed, operating at 24-V dc, nominal.
      d. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACU.
      e. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. The fixed base shall be designed for mounting directly to the air duct. Provide terminals in the fixed base for connection to building wiring.
      f. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
      g. Integral Visual-Indicating Light: LED type. Indicating detector has operated and power-on status. Provide remote status and alarm indicator and test station as shown on Drawings.
      h. Remote Control: Detectors shall be analog-addressable type, individually monitored at the FACU for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACU.
      i. Each sensor shall have multiple levels of detection sensitivity.
      j. Sampling Tubes: Design and dimensions as recommended by manufacturer for the specific duct size, air velocity, and installation conditions where applied.

   2. Remote Duct Smoke Detector Test Station:
      a. Alarm/power LED on faceplate.
      b. Flush ceiling mounted in finished areas and surface wall mounted or group wall mounted in equipment rooms.
      c. White lettering on red nameplate identifying associated detector(s).
2.10 NON-SYSTEM DETECTORS

A. Carbon Monoxide Detector:
   1. UL 2075 listed, operating at 120V ac.
   2. Auxiliary Relays: one Form C.
   3. Audible Notification Appliance: Piezoelectric sounder rated at 90 dBA at 10 feet (3 m) according to UL 404.
   5. Tandem Connection: Allow tandem connection of number of indicated detectors; alarm as one detector shall actuate notification on all connected detectors.
   6. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
   7. Self-Restoring: Detectors shall not require resetting as readjustment after activation to restore them to normal operation.
   8. Suitable for mounting to flush junction box.

2.11 HEAT DETECTORS

A. General: UL 521 listed selectable as fixed temperature or combination fixed/rate-of-rise operation as described herein. Heat detectors shall also be programmed as a low temperature utility sensor when ambient temperature drops below 40 degrees F. Heat detectors shall be of the bi-metal restorable type.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature and/or rate-of-rise of temperature that exceeds 15 deg F (8 deg C) or 20 degree F (11 degree C) selectable at the FACU per minute as shown on Drawings.
   2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACU.

C. Heat Detector, Fixed Temperature Type: Actuated by temperature that exceeds a fixed temperature selectable as 135 degree F (57.2 degree C) or 155 degree F (68 degree C) as shown on Drawings.
   2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACU.

D. Where ambient conditions preclude the use of addressable devices, equivalent conventional devices, rated for the environment shall be used. Each device shall be monitored by a dedicated addressable module located in a conditioned space.

2.12 FIRE ALARM NOTIFICATION APPLIANCES

A. Description: Equipped for mounting generally as shown on Drawings and with screw terminals for system connections.

B. Audibility and Intelligibility Requirements:
   1. Suitable per NFPA 72 and local requirements.
2. Be responsible to meet requirements using manufacturer specific notification appliances whose tap settings are generally set at the lower (1/2 watt) of their associated range and main power supplies and amplifiers with 25 percent minimum spare capacity above sum of all devices at maximum tap settings. Contract Drawing layouts depict generic industry solution approaches. Add notification appliances at no cost to Owner to meet these requirements. Submit design compliance per Pre-Installation Shop Drawing Submittal requirements.

3. Design compliance to acknowledge the following minimum acoustical layout criteria:
   a. Published anticipated average ambient room sound levels.
   b. Loss of dBA for barriers:
      1) Stud/Drywall Walls: 35-50
      2) Doors: 15-20
      3) Drywall: 15-20
      4) Wall Coverings: 3-5
   c. Space acoustical characteristics.
   d. Speakers set at lower tap settings generally provide better intelligibility and more uniform sound levels.
   e. Speakers in equipment rooms shall be set at minimum 2 watt tap setting.
   f. Maximum occupant distance from a speaker is 50 feet.

C. Voice/Tone Speakers:
   1. UL 1480 listed.
   2. General Type Low-Range Units: Rated 1 to 2 W.
   3. Horn Type High-Range Units: Rated 2 to 15 W.
   4. Mounting: Flush, semi-recessed, or surface mounted; bidirectional as shown on Drawings. Flush ceiling speakers shall have round white grill. Surface ceiling speakers shall have backbox sized larger that grill.
   5. Matching Transformers: Tap range matched to the acoustical environment of the speaker location.

D. Visible Alarm Devices: System synchronized xenon strobe lights listed under UL 1971, with clear polycarbonate lens mounted on faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.
   1. Rated Light Output: As shown on Drawings.
   2. Strobe Leads: Factory connected to screw terminals.
   3. Synchronization of strobes shall be accomplished via software programming systems that required field modules and synchronization circuits will be not considered acceptable.
   4. Unless indicated otherwise ceiling mounted devices shall be white.
   5. Unless indicated otherwise wall mounted devices shall be red.

E. Notification Appliance Circuit (NAC) Extender Panel: The NAC extender panel shall function as a wiring termination and data collection point on each floor.
   1. Provide additional notification appliance circuit capacity and synchronization for new and existing visible alarm devices. Size panel as required.
   2. The NAC extender panel may be mounted close to the host FACU or (FPU) or can be remotely located and shall connect to the host panel via a communications channel. Each output NAC can be individually controlled for general alarm or selective area notification as required by the area and function.
3. Alarms from the host fire panel shall signal the NAC power extender panel to activate. The panel shall monitor itself and each of its NACs for trouble conditions and shall report trouble conditions to the host panel.

2.13 MAGNETIC DOOR AND GATE HOLDERS
A. Supplied by Division 08, installed and wired by Division 28.
B. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching door/gate plate.
   1. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
   2. Wall-Mounted Units: Flush mounted, unless otherwise indicated.
   3. Rating: Tri-voltage design to accommodate 12VDC, 24VDC, 24VAC or 120VAC

2.14 WATERFLOW ALARM, WATERFLOW SUPERVISORY TAMPER, AND DRY PIPE PRESSURE SWITCHES
A. Supplied and installed by Division 21, wired by Division 28.

2.15 ADDRESSABLE RELAY
A. Description: Microelectronic monitor module listed for use in providing a system address for listed alarm-initiating devices for hard-wired applications with auxiliary contacts such as non-system detectors, workflow switches, tamper switches.
   1. Integral Relay: Provides a direct control signal for hard-wired applications with input contacts such as elevator recall, shunt trip, door release, smoke hatch release, fan shutdown, etc.
      a. Minimum relay quantities for door releases shall be by floor (per FPU) to control all door releases in the area.
      b. Provide individual relay for each auto operated door in a rated wall to automatically shunt power to unit during fire alarm.
   2. Relay modules shall be mounted flush in ceiling and be readily accessible and visible where located in finished spaces.

2.16 ADDRESSABLE RELAY MODULES CABINET
A. Addressable modules, dependent on location, may, at Division 28 discretion, be mounted in cabinets in mechanical/electrical rooms for interaction/connection with room devices or be mounted as an integral part of the FPU cabinets.

2.17 WIRE GUARDS FOR PHYSICAL PROTECTION
A. Description: Welded wire mesh of size and shape for the smoke detector, audible device, visual devices, or other device requiring protection as shown on Drawings.
   1. Construction and Finish: Per Division 26 Section "Wiring Devices."

2.18 WIRE AND CABLE
A. Wire and cable for fire alarm systems shall be UL listed and labeled as complying with NFPA 70, Article 760.
   1. Limit circuit voltage drop to 10 percent maximum.
B. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG size as recommended by system manufacturer.

C. Circuit Integrity Cable: Twisted shielded pair, NFPA 70 Article 760, Classification CI, for power-limited fire alarm signal service. UL listed as Type FPL, and complying with requirements in UL 1424 and in UL 2196 for a 2-hour rating.
   1. Notification appliance circuits passing through a separate fire zone shall be 2-hour rated per UL 2196.
   2. Backbone communication circuits between FACU and FPU’s shall be 2-hour rated per UL 2196.

   1. Low-Voltage Circuits: No. 18 AWG, minimum.
   2. Line-Voltage Circuits: No. 12 AWG, minimum.
   3. Multiconductor Armored Cable: NFPA 70 Type MC, copper conductors, TFN/THHN conductor insulation, copper drain wire, copper armor with red identifier stripe, UL listed for fire alarm and cable tray installation, plenum rated, and complying with requirements in UL 2196 for a 2-hour rating.

E. Fire alarm cable shall be red in color with label/printing appropriate for the application; refer to Division 26 Section "Electrical Identification".

2.19 OPTICAL FIBER CABLE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Belden, Inc.
   2. CommScope, Inc.
   3. Corning Incorporated.
   4. Emerson Connectivity Solutions.
   5. General Cable Technologies Corporation.
   6. Mohawk; a division of Belden, Inc.
   7. Nexans; Berk-Tek Products.
   8. Siemon Company (The).
   10. SYSTIMAX Solutions; a CommScope, Inc. brand.
   11. 3M.
   12. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: Single-mode, 50/125-micrometer, fiber, nonconductive, tight-buffer, optical-fiber cable.
   1. Comply with ICEA S-83-596 for mechanical properties.
   2. Comply with TIA-568-C.3 for performance specifications.
   4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70.

C. Jacket:
   1. Jacket Color: Provide per Owner standards. Refer to Division 26 Section "Electrical Identification".
   2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

2.20 OPTICAL-FIBER CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following

1. ADC.
3. Belden, Inc.
5. Dynacom, Inc.
7. Molex Premise Networks; a division of Molex, Inc.
8. Panduit Corp.
9. Siemon Company (The)

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

C. Patch Cords: Factory-made, dual-fiber cables.

D. Cable Connecting Hardware:

2. Quick-connect, simplex and duplex, Type LC connectors. Insertion loss of not more than 0.75 dB.
3. Type SFF connectors may be used in termination racks, panels, and equipment packages.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Connecting to Existing Equipment: Verify that existing fire alarm system is operational before making changes or connections.

1. Connect new equipment to the existing control panel in the existing part of the building.
2. Connect new equipment to the existing monitoring equipment at the Supervising Station.
3. Expand, modify, and supplement the existing control and monitoring equipment as necessary to extend the existing control and monitoring functions to the new points. New components shall be capable of merging with the existing configuration without degrading the performance of either system.
4. Ensure proper system operation and code compliant system operation all the time.

B. Install equipment mounting heights in accordance with State, Local Fire Alarm Codes, and Handicapped Codes.

C. Install devices being conscious of exact placements per NFPA 72. The Drawings are diagrammatic.
D. Install device boxes of size and type recommended by manufacturer’s representative to suit device and location shown on Drawings. Paint boxes per Division 26 Section "Boxes and Cabinets". Install FPU, NAC extender panel and FATC cabinets at five feet above floor to center, unless otherwise noted, supported independently from stud partitions.

E. Install minimum quantity of FPU’s and FATC’s; as shown on Drawings to meet survivability and wiring homerun design intent.

F. Overcurrent device location shall be identified with appropriate nameplate at the FACU’s, FPU’s, NACs, Audio Amplifiers and all other fire alarm power supply units. Refer to Division 26 Section “Electrical Identification”. Provide breaker handle clips in on position and "Fire Alarm System" nameplate at all panelboard breakers serving the fire alarm equipment.

G. Place batteries in the FACU, FPU’s or similar type enclosure located next to the control unit. Batteries which vent explosive hydrogen gas (gelled-electrolyte, lead-calcium, lead-antimony, and nickled-cadmium) shall not be placed in the same enclosure as the fire alarm control panel. Such batteries shall be placed in an area with suitable ventilation. It shall be the responsibility of the fire alarm supplier to advise the engineer and contractor at bid time of any special ventilation requirements not provided as part of the fire alarm contract.

1. Provide framed glass print of appropriate zoning diagram adjacent to each FACU, FPU and ECCU.

H. System Smoke or Heat Detector Spacing:

1. Smooth ceiling spacing shall not exceed 30 feet (9 m).
2. Spacing of heat detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas, shall be determined according to Appendix A in NFPA 72.
3. Spacing of heat detectors shall be determined based on guidelines and recommendations in NFPA 72.
4. HVAC: Locate detectors not closer than 3 feet (1 m) from air-supply diffuser or return-air opening.
5. Mount detector bases on ceiling boxes such that the indicator lamps are visible from the floor below (lined up in corridor applications) or from the nearest equipment aisle or from the doorway entering the room.

I. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of the duct and are mounted near the top third on the side of a duct. Provide remote duct smoke detector test station for each duct smoke detector.

J. Locate fan shutdown control modules within three (3) foot of associated fan controller, unless hardwired to local FPU. In either case, an individual addressable alarm point is required.
2. Size raceways and associated boxes as required by the National Electrical Code limiting fill to 30 percent unless otherwise indicated or further reduced by manufacturer’s representative’s recommendations. Terminate all conduits with plastic bushings.

3. Connect all devices mounted on suspended ceilings to securely mounted junction boxes with enough wiring to move the device five (5) feet in any direction.

4. Fire alarm conduit shall be red in color; refer to Division 26 Section “Electrical Identification”.

C. Wiring Method:

1. Provide interconnecting wire and cable between the various system devices for proper system operation as recommended by the manufacturer’s representative.

2. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.

3. Fire Rated Cables: Provide 2-hour fire rated fire alarm cables, NFPA 70 Type MI, NFPA 70 Type CI with associated metallic conduit to meet 2-hour rating, or 2-hour enclosure for:
   a. Looped backbone FPU communication risers.
   b. Notification appliance circuits until they enter the evacuation signaling zone that they serve.
   c. Class A return loop when passing through separate fire zone(s).

4. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or raceway as signaling line circuits.

5. ECCU Speaker Circuits: Alternate circuits to local speakers from physically separate homeruns to associated (FPU or) FACU.

6. Provide push-in wire connectors and make splice connection to each device to facilitate device maintenance.

D. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

E. Cable Terminations: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

F. Color Coding: Color code fire alarm conductors differently from the normal building power wiring. Use one color code for alarm circuit wiring and a different color code for supervisory circuits. Color code audible alarm indicating circuits differently from alarm initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system raceway couplings, junction boxes and covers red. Provide red colored conduit.

G. Backbone FPU Communication Risers: Install at least two vertical 2-hour fire-rated fire alarm cable risers to serve the fire alarm system. Separate risers physically minimum 40 foot apart in separate rooms.

H. Wiring to Remote Alarm Transmitting Device: 1-inch (25-mm) conduit between the FACU and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

I. Circuits:

1. Initiating Device Circuits: NFPA 72, Class B
a. Except if leaving fire zone or floor or as otherwise required by code, provide Class A  

2. Notification Circuits: NFPA 72, Class B  
   a. Except if leaving fire zone or floor or as otherwise required by code, provide Class A.  
   b. System Layout: Install no more than 20 addressable devices on each signaling line circuit complete with associated isolator module.  

3. Signaling Line Circuits: NFPA 72, Class A.  

3.3 IDENTIFICATION  
   A. Identify system components, wiring, cabling, and terminals according to Division 26 Section "Electrical Identification."  
   B. Install framed operating instructions in a location visible from the FACU.  
   C. Paint power-supply disconnect switch red and label "FIRE ALARM."  
   D. Mark each addressable device with system device address per Owner requirements. Obtain inspecting tags from owner or owner’s vendor. Labels shall be legible when viewed from the floor without the need for a ladder.  

3.4 GROUNDING  
   A. Ground the FACU and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to the FACU.  
   B. Ground equipment and conductor and cable shields. For audio circuits, minimize to the greatest extent possible group loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.  

3.5 FIELD QUALITY CONTROL  
   A. Manufacturer’s Field Service: Engage a factory-authorized service representative to supervise field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.  
   B. Perform the following field tests and inspections and prepare test reports:  
      1. Before requesting final approval of the installation, submit a written statement using the form for Record of Completion shown in NFPA 72.  
      2. Perform each electrical test and visual and mechanical inspection listed in NFPA 72. Certify compliance with test parameters. All tests shall be conducted under the direct supervision of a NICET technician certified under the Fire Alarm Systems program at Level III.  
         a. Include the existing system in tests and inspections.  
      3. Visual Inspection: Conduct a visual inspection before any testing. Use as-built drawings and system documentation for the inspection. Identify improperly located, damaged, or nonfunctional equipment, and correct before beginning tests.  
      4. Testing: Follow procedure and record results in the form of a record of completion complying with requirements in NFPA 72.  
         a. Detectors that are outside their marked sensitivity range shall be replaced.
5. Test and Inspection Records: Prepare according to NFPA 72, including demonstration of sequences of operation by using the matrix-style form in NFPA 72.

C. Repeat the complete field tests and inspections of the entire system at the 11 month point of the one year warranty period.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

B. Follow-Up Tests and Inspections: After date of Substantial Completion, test the fire alarm system complying with testing and visual inspection requirements in NFPA 72.

3.7 SYSTEM CERTIFICATION AND TESTING DOCUMENTATION

A. Submit written certification documenting successful completion of all system required testing. This certification and documentation shall include certification that the system:

1. Has been visually inspected and functionally tested by a manufacturer's certified representative. Documentation shall include:
   a. The date and time of each test.
   b. A reference set of record drawings, numerically identifying the individual components and circuits tested.
   c. A description of each test/verification performed.
   d. A checklist of each device and circuit test, indicating the results of each test. Include speaker tap setting list and initiating device time/sensitivity setting list.
   e. A narrative sequence of operations for all associated evacuation signaling and auxiliary functions, including a verification checklist documenting correct operation.
   f. The names and signatures of the individuals conducting and witnessing each test.
   g. A checklist of test results for signaling between related systems including:
      1) Division 23 BAS for fan shutdown, damper, and smoke control.
      2) Division 14 elevator recall and shutdown.
      3) Division 21 fire pump signaling.
      4) Division 21 fire suppression signaling.
      5) Division 21 fire protection signaling.
      6) Division 08 for hardware interface such as door and smoke hatch releases.
      7) Security system signaling for door release(s).

2. Is installed entirely in accordance with the manufacturer's recommendations and within the limitations of the required listings and approvals.

3. Is in proper working order and in full compliance with Contract Documents.

4. Has latest version of manufacturer's software and graphics. Include appropriate listing.

B. Note: Multiple tests may be required depending upon approval of suggested Division 28 phasing.
3.8 RECORD DRAWINGS
A. Upon completion of the installation, record drawings shall be submitted on each system before final acceptance of the work. Furnish to the Engineer a set of record drawings including system diagrams for each system. The record drawing masters shall be on reproducible Mylar film. Uniformly sizes as required for legibility and reproduction and on high density floppy disks in latest Autocad Version format. (Note that contract document drawings are available from the Architect on floppy disk for a negotiated fee.) Record drawings shall illustrate all peripheral device locations including final address, major equipment locations, zoning, conduit routing, single line riser diagram depicting wiring characteristics and termination designations for all devices. Also included shall be documentation of spare raceways, new and existing, either unused or vacated by removal of existing systems.

3.9 TRAINING
A. For new facilities provide the services of a factory authorized service representative to demonstrate and train the facilities maintenance personnel as specified below.
B. Train facilities maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventive maintenance of the system. Training shall also include complete user software/graphics changeability by Staff Personnel. Future voice message changes shall be implemented through local supplier to ensure integrity/reliability of audible alarm functions. Provide a minimum of 4-hour training session for ten (10) facility staff total.
C. The session shall be videotaped with 2 DVD copies turned over to the Owner upon completion. Include:
   1. Permanent training manuals as well as ten (10) individual training manuals broken apart by training session.
   2. All costs associated with training at the facility in a classroom environment.
   3. An hourly rate for training beyond the specified sessions shall be presented to the Owner.
   4. All standard manufacturer training video tapes and manuals as part of permanent training manuals.
D. Coordinate and schedule training with the facility at least one month in advance.

3.10 DEMONSTRATION
A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the fire alarm system, appliances, and devices. Refer to Division 01 Section "Demonstration and Training."
A. Standard non-smoke purge air handling systems:

<table>
<thead>
<tr>
<th>EVENT (DEVICE ACTIVATED)</th>
<th>CONTROLLED RESPONSES PER SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SUPERVISORY SIGNAL VIA FIRE ALARM (NFPA 99 15.7.4.2.2, NFPA 90A 6.4.4.2.1 &amp; NFPA 101 10.5.3.2.2)</td>
</tr>
<tr>
<td>CORRIDOR SMOKE DETECTOR</td>
<td>X</td>
</tr>
<tr>
<td>OTHER AREA SMOKE DETECTOR</td>
<td>X</td>
</tr>
<tr>
<td>SMOKE DETECTORS USED IN LIEU OF DUCT DETECTORS** (IBC 716.3.3.2)</td>
<td>X</td>
</tr>
<tr>
<td>DUCT DETECTORS REMOTE OF THE AHU (SUPPLY &amp; RETURN)</td>
<td>X</td>
</tr>
<tr>
<td>DUCT DETECTOR(S) AT AHU RETURN</td>
<td>X</td>
</tr>
<tr>
<td>DUCT DETECTOR(S) AT AHU SUPPLY</td>
<td>X</td>
</tr>
<tr>
<td>IF AHU SERVES MULTIPLE FLOORS, DUCT DETECTORS AT SHAFT WALLS OR FLOOR PENETRATIONS.</td>
<td>X</td>
</tr>
<tr>
<td>AHU OFF FOR ANY REASON</td>
<td>X</td>
</tr>
</tbody>
</table>

* TWO SUPERVISORY SIGNALS, WITHIN THE SAME BUILDING OR A BUILDING WHICH SHARES A FIRE ALARM PANEL, WOULD INITIATE A FIRE ALARM SEQUENCE.
** IF APPLICABLE, THIS WILL BE EVALUATED ON A CASE BY CASE BASIS
*** SYSTEM NEEDS TO BE EVALUATED TO ENSURE DUCTWORK PRESSURE IS REGULATED PROPERLY WITHOUT SHUTTING DOWN UNIT.
**** REFER TO SMOKE PURGE SYSTEM SEQUENCE ON THE DRAWINGS.
### Exhaust Fans:

**Exhaust Fans Fire Alarm and Mechanical Controls Matrix**

<table>
<thead>
<tr>
<th>Event (Device Activated)</th>
<th>Supervisory Signal via Fire Alarm</th>
<th>Trouble Signal via Fire Alarm</th>
<th>Alarm Signal via Fire Alarm</th>
<th>Smoke Purge Mode via Fire Alarm (NFPA 90A 6.4.3.2)</th>
<th>Shut Down Fans via Fire Alarm (NFPA 90A 6.4.3.1 &amp; 6.4.2.3)</th>
<th>Control Damper Associated with Duct Detector</th>
<th>Close the AHU Return Control Damper via BAS</th>
<th>VaV Setting for Room Which Detected Smoke, Set via BAS</th>
<th>VaV Settings for All Other Rooms, Set via BAS</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Duct Detector Within Exhaust System</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Code Allows Either Supervisory or Alarm Signal</td>
</tr>
<tr>
<td>Smoke Detectors Used in Lieu of Duct Detectors** (IBC 716.3.3.2)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Code Allows Either Supervisory or Alarm Signal</td>
</tr>
<tr>
<td>Any Smoke Detector in Room(s) Served by Fan</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Code Allows Either Supervisory or Alarm Signal</td>
</tr>
<tr>
<td>Fan Off for Any Reason</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

**Notes:**
- This matrix is applicable only for exhaust fans per NFPA 90A (2009), NFPA 99 (2009), IBC (2009) and IMC (2009).
- **Two supervisory signals, within the same building or a building which shares a fire alarm panel, would initiate a fire alarm sequence.**
- **If applicable, this will be evaluated on a case by case basis.**
- **System needs to be evaluated to ensure ductwork pressure is regulated properly without shutting down unit.**
- ****Refer to smoke purge system sequence on the drawings.
C. Smoke Purge Air Handling Systems:
<table>
<thead>
<tr>
<th>EVENT (DEVICE ACTIVATED)</th>
<th>CONTROLLED RESPONSES PER SYSTEM</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SUPERVISORY SIGNAL VIA FIRE ALARM</strong> (NFPA 99 15.7.4.2.2, NFPA 90A 6.4.2.1 &amp; NFPA 101 9.63.2.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TROUBLE SIGNAL VIA FIRE ALARM</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SMOKE PURGE MODE VIA FIRE ALARM</strong> (NFPA 90A 6.4.3.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SHUT DOWN FANS VIA FIRE ALARM</strong> (NFPA 90A 6.4.3.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CLOSE LOCAL DAMPER ASSOCIATED WITH DUCT DETECTOR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CLOSE ALL SMOKE DAMPER VIA FIRE ALARM</strong> (NFPA 90A 6.3.3 &amp; IBC 716.3.3.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CLOSE THE AHU RETURN CONTROL DAMPER VIA BAS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VAI SETTING FOR ROOM WHICH DETECTED SMOKE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VAI SETTINGS FOR ALL OTHER ROOMS SET VIA BAS</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### OUTSIDE RED LINE

| CORRIDOR SMOKE DETECTOR | X | X | X | NORMAL | NORMAL |
| OTHER AREA SMOKE DETECTOR | X | X | X | NORMAL | NORMAL |
| SMOKE DETECTORS USED IN LIEU OF DUCT DETECTORS** (IBC 716.3.3.2) | X | X | X | NORMAL | NORMAL |
| DUCT DETECTORS REMOTE OF THE AHU (SUPPLY & RETURN) | X | X | X | NORMAL | NORMAL |
| DUCT DETECTOR(S) AT AHU RETURN | X | X | X | NORMAL | NORMAL |
| DUCT DETECTOR(S) AT AHU SUPPLY | X | X | X | NORMAL | NORMAL |
| IF AHU SERVES MULTIPLE FLOORS, DUCT DETECTORS AT SHAFT WALLS OR FLOOR PENETRATIONS. | X | X | X | NORMAL | NORMAL |
| AHU OFF FOR ANY REASON | X | NORMAL | NORMAL |

### WITHIN RED LINE

| OR/PROCEDURE ROOM DETECTOR (CEILING OR DUCT) | X | X | X | SMOKE PURGE | NORMAL | REFER TO MECHANICAL PLANS FOR SMOKE PURGE VAV SETTINGS |
| CORRIDOR SMOKE DETECTOR | X | X | X | NORMAL | NORMAL |
| OTHER AREA SMOKE DETECTOR | X | X | X | NORMAL | NORMAL |
| SMOKE DETECTORS USED IN LIEU OF DUCT DETECTORS** (IBC 716.3.3.2) | X | X | X | NORMAL | NORMAL |
| DUCT DETECTOR REMOTE OF THE AHU (SUPPLY/RETURN) | X | X | X | NORMAL | NORMAL |
| DUCT DETECTOR(S) AT AHU RETURN | X | X | X | NORMAL | NORMAL |
| DUCT DETECTOR(S) AT AHU SUPPLY | X | X | X | NORMAL | NORMAL |
| IF AHU SERVES MULTIPLE FLOORS, DUCT DETECTORS AT SHAFT WALLS OR FLOOR PENETRATIONS. | X | X | X | NORMAL | NORMAL |
| AHU OFF FOR ANY REASON | X | NORMAL | NORMAL |

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* TWO SUPERVISORY SIGNALS, WITHIN THE SAME BUILDING OR A BUILDING WHICH SHARES A FIRE ALARM PANEL, WOULD INITIATE A FIRE ALARM SEQUENCE.

** IF APPLICABLE, THIS WILL BE EVALUATED ON A CASE-BY-CASE BASIS.

*** SYSTEM NEEDS TO BE EVALUATED TO ENSURE DUCTWORK PRESSURE IS REGULATED PROPERLY WITHOUT SHUTTING DOWN UNIT.

**** REFER TO SMOKE PURGE SYSTEM SEQUENCE ON THE DRAWINGS.

***** FOR EXHAUST FANS, THE BAS SHALL SEND A SIGNAL TO THE FIRE ALARM THAT THE FAN IS OFF.
END OF SECTION 283100