BOTETOURT COUNTY, VIRGINIA

FOR CONSTRUCTION OF

RMFDE – 911 COMPLEX

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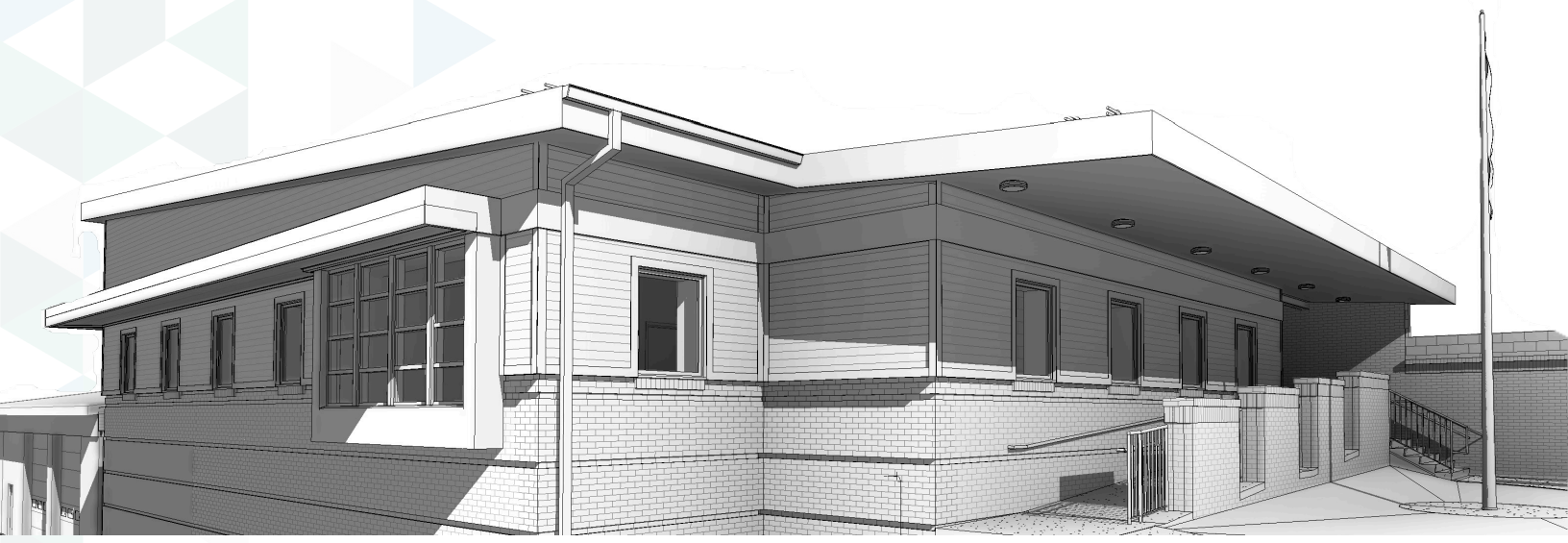

ARCHITECTURAL PARTNERS

MN STUDIOS ARCHITECTURE INTERIOR DESIGN

MASTER ENGINEERS & DESIGNERS

HURT&PROFFITT

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SECTION 211000
WATER-BASED FIRE-SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Submittals:
   1. Product Data for valves, sprinklers, specialties, and alarms.
   2. Submit sprinkler system drawings identified as "working plans" and calculations according to NFPA 13. Submit required number of sets to authorities having jurisdiction for review, comment, and approval. Include system hydraulic calculations.
   3. Submit test reports and certificates as described in NFPA 13.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Design and Installation Approval: Acceptable to authorities having jurisdiction.
B. Hydraulically design sprinkler systems according to NFPA 13.
C. Comply with NFPA 13 and NFPA 70.
D. UL-listed and -labeled and FM-approved pipe and fittings.

2.2 PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795.
B. Cast-Iron Threaded Flanges: ASME B16.1, Class 250, raised ground face, bolt holes spot faced.
C. Cast-Iron Threaded Fittings: ASME B16.4, Class 250, standard pattern.
D. Grooved-End Fittings: UL-listed and FM-approved, ASTM A 536, Grade 65-45-12 ductile iron or ASTM A 47, Grade 32510 malleable iron, with grooves or shoulders designed to accept grooved couplings.
E. Grooved-End Couplings: UL 213, ASTM A 536 ductile-iron or ASTM A 47 malleable-iron housing, with enamel finish. Include gaskets, bolts, and accessories.
F. Steel Press-Seal Fittings: UL 213, FM approved, 175-psig pressure rating, for use with Schedule 5, plain-end, steel pipe and fittings; with butylene O-rings, and pipe stop.
G. Provide hangers, supports, and seismic restraints with UL listing and FM approval for fire-protection systems.

2.3 VALVES

A. Two-Piece Ball Valves with Indicators:
   1. Description: UL 1091, and FM Global Class Number 1112, Forged brass or bronze, 175 psig working pressure.
   2. End Connections for Valves NPS 1 through NPS 2: Threaded ends.
   3. End Connections for Valves NPS 2-1/2: Grooved ends.
B. Bronze Butterfly Valves with Indicators:
   1. Description: UL 1091 and FM Global Class Number 1112, Bronze, 175 psig working pressure.
   2. End Connections for Valves NPS 1 through NPS 2: Threaded ends.
   3. End Connections for Valves NPS 2-1/2: Grooved ends.
C. Bronze OS&Y Gate Valves:
   1. Description: UL 262, cast bronze, solid wedge, outside screw and yoke, rising stem, 175 psig working pressure.
D. Check Valves:
   1. Description: UL 312 and FM Global standard for swing check valves, Class Number 1210, 175 psig working pressure, cast iron, or bronze with bronze clapper.
E. Alarm Check Valves:

1. Description: UL 193, 175-psig working pressure, designed for horizontal or vertical installation, with cast-iron, bronze grooved seat with O-ring seals, and single-hinge pin and latch design. Include trim sets for bypass, drain, electric sprinkler alarm switch, pressure gages, retarding chamber, fill-line attachment with strainer, and drip cup assembly.

F. Automatic (Ball Drip) Drain Valves:
1. Description: UL 1726, 175-psig working pressure NPS 3/4, ball check device with threaded end connections.

2.4 SPRINKLERS

A. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide" listing published by FM Global.
1. Pressure Rating for Automatic Sprinklers: 175 psig minimum.

B. Automatic Sprinklers with Heat-Responsive Element:
1. Nonresidential Applications: UL 199
2. Early-Suppression, Fast-Response Applications: UL 1767.
3. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

C. Sprinkler Finishes: Chrome plated

D. Sprinkler Escutcheons (for Ceiling and Sidewall Mounted): White enamel, steel, one piece, flat.

E. Sprinkler Guards:
1. Description: UL 199, wire cage with fastening device for attaching to sprinkler.

F. Sprinkler Cabinets: Finished steel cabinet and hinged cover, with space for minimum of six spare sprinklers plus sprinkler wrench, suitable for wall mounting. Include number of sprinklers required by NFPA 13 and one wrench for sprinklers. Include separate cabinet with sprinklers and wrench for each style sprinkler on Project.

2.5 PIPING SPECIALTIES AND ALARM DEVICES

A. Wall-Type Fire Department Connection:
1. Description: UL 405, flush, with cast-brass body; NH-standard thread inlets matching local fire department threads.
2. Finish: Rough brass or bronze

B. Water-Motor-Operated Alarms:
1. Description: 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.

C. Water-Flow Indicators:
1. Description: UL 346, electrically supervised, paddle-type, with 250-psig pressure rating; and designed for horizontal or vertical installation. Include two SPDT 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.

D. Pressure Switches:
1. Description: UL 346, electrical-supervision-type, water-flow switch with retard feature. Include SPDT, normally closed contacts and design that operates on rising pressure and signals water flow.

E. Valve Supervisory Switches:

1. Description: UL 346, electrically supervised; SPDT, with normally closed contacts. Include design that signals controlled valve is in other than fully open position.

F. Pressure Gages:
1. Description: UL 393, 3-1/2- to 4-1/2-inch-diameter dial with dial range of 0 to 250 psig.

2.6 SLEEVES

A. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.7 SLEEVE-SEAL SYSTEMS

A. 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: Carbon steel
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.8 FLOOR PLATES

A. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 GENERAL PIPING INSTALLATIONS

A. Install piping free of sags and bends.

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

C. Sleeves:
1. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
2. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
3. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

D. Escutcheons and Floor Plates:
1. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
2. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
3. Install floor plates for piping penetrations of equipment-room floors.
4. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

E. Install unions at final connection to each piece of equipment.

3.2 SERVICE-ENTRANCE PIPING

A. Connect sprinkler piping to sprinkler-service piping systems.

B. Install shutoff valve, backflow preventer, pressure gage, and drain indicated at connection to water-service piping.

3.3 SPRINKLER PIPING INSTALLATION

A. Install "Inspector's Test Connections" in sprinkler piping, complete with shutoff valve.

B. Install sprinkler zone control valves, test assemblies, and drain headers adjacent to standpipes.

C. Install ball drip valves to drain piping between fire department connections and check valves. Drain to floor drain or outside building.
D. Install alarm devices in piping systems and connect to fire-alarm system.
E. Protect piping from earthquake damage as required by NFPA 13.
F. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Install gages to permit removal, and install where they will not be subject to freezing.
G. Install fire-protection service valves supervised-open, located to control sources of water supply except from fire department connections. Where there is more than one control valve, provide permanently marked identification signs indicating portion of system controlled by each valve.
H. Install check valve in each water supply connection. Install backflow preventers in potable-water supply sources.
I. Install alarm check valves for proper direction of flow, including bypass check valve and retard chamber drain line connection.

3.4 SPRINKLER SCHEDULE

A. Rooms without Ceilings: Upright sprinklers.
B. Rooms with Suspended Ceilings: Concealed sprinklers with white enamel cover.
C. Wall Mounting: Institutional, flush, sidewall sprinklers.
D. Sprinklers Subject to Freezing: Upright, pendent, or sidewall dry sprinklers as indicated.
E. Special Applications: Extended coverage or quick-response sprinklers as indicated.
F. Sprinkler Finishes: Chrome plated in finished spaces and rough bronze in unfinished spaces. Provide white enamel escutcheons in finished spaces.
G. Install sprinklers in suspended ceilings in center of ceiling panels.

3.5 PIPING SCHEDULE

A. Use steel pipe with threaded, press-seal, roll-grooved, or cut-grooved joints.
   1. For steel pipe joined by threaded fittings, use Schedule 40.
   2. For steel pipe joined by welding or roll-grooved pipe and fittings, use Schedule 10.
   3. For steel pipe NPS 2 and smaller, joined by press-seal fittings, use Schedule 5 pipe, fabricated with manufacturer's press-seal tools.
B. Pipe between Fire Department Connections and Check Valves: Use galvanized-steel pipe with flanged or threaded joints.

3.6 TESTING

A. Flush, test, and inspect sprinkler piping systems according to NFPA 13.

END OF SECTION

SECTION 220517
SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Sleeves without waterstop.
   2. Sleeves with waterstop.

PART 2 - PRODUCTS

2.01 SLEEVES WITHOUT WATERSTOP

A. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.

2.02 SLEEVES WITH WATERSTOP

A. Description: Manufactured galvanized steel, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.

PART 3 - EXECUTION

3.01 INSTALLATION OF SLEEVES - GENERAL

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
B. Select sleeves of size large enough to provide 1-inch 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 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 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.
E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.02 INSTALLATION OF SLEEVES WITH WATERSTOP

A. Install sleeve with waterstop as new walls and slabs 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 or fire-resistant silicone sealant, seal the space around outside of sleeves.

3.03 INSTALLATION OF STACK-SLEEVE FITTINGS

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch 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 Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches 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 waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.04 SLEEVE SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:
   1. Exterior Concrete and Masonry Walls above and below Grade:
      a. Sleeves with waterstops.
         1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   2. Concrete Slabs-on-Grade:
      a. Sleeves with waterstops.
         1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   3. Interior Partitions:
      a. Sleeves without waterstops.

END OF SECTION

SECTION 220518
ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Escutcheons.
   2. Floor plates.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

2.02 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.

2.03 FLOOR PLATES

A. Split Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.01 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 insulated 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.
      b. Chrome-Plated Piping: One-piece steel with polished, chrome-plated finish.
      c. Insulated Piping: One-piece steel with polished, chrome-plated finish.

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.

3.02 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION

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SECTION 220519
METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Liquid-in-glass thermometers.
   2. Pressure gages.
   3. Gage attachments.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.03 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.01 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
   1. Standard: ASME B40.200.
   2. Case: Cast aluminum; 6-inch nominal size.
   3. Case Form: Back angle unless otherwise indicated.
   4. Tube: Glass with magnifying lens and red organic liquid.
   5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
   6. Window: Glass or plastic.
   7. Stem: Aluminum or brass and of length to suit installation.
      a. Design for Thermowell Installation: Bare stem.
   8. Connector: 3/4 inch, with ASME B1.1 screw threads.
   9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of suitable scale range.

2.02 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
   1. Standard: ASME B40.100.
   2. Case: cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
   3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
   4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
   5. Movement: Mechanical, with link to pressure element and connection to pointer.
   6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
   7. Pointer: Dark-colored metal.
   8. Window: Plastic.
   9. Ring: Brass.
   10. Accuracy: Grade A, plus or minus 1 percent of middle half of suitable scale range.

2.03 GAGE ATTACHMENTS

A. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

B. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

3.02 ADJUSTING

A. Adjust faces of meters and gages to proper angle for best visibility.

END OF SECTION

SECTION 220523.14
CHECK VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Bronze, swing check valves.

1.02 DEFINITIONS

A. CWP: Cold working pressure.
B. EPDM: Ethylene propylene-diene terpolymer.
C. NBR: Nitrile butadiene rubber (also known as Buna-N).

1.03 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, press connections, and weld ends.
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.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

A. Standards:
   1. Domestic water piping check valves intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), requirements of authorities having jurisdiction, and NSF 61/NSF 372, or to be certified in compliance with NSF 61/NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.
B. ASME Compliance:
   1. ASME B1.20.1 for threads for threaded end valves.
   2. ASME B16.1 for flanges on iron valves.
   3. ASME B16.5 for flanges for metric standard piping.
   4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   5. ASME B16.18 for cast-copper solder joint.
   6. ASME B16.22 for wrought copper solder joint.
   7. ASME B16.51 for press joint.
   8. ASME B31.9 for building services piping valves.
C. AWWA Compliance: Comply with AWWA C606 for groove-end connections.
D. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.
E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
F. Valve Sizes: Same as upstream piping unless otherwise indicated.

2.03 BRONZE SWING CHECK VALVES

A. Bronze, Swing Check Valves with Bronze Disc, Class 125:
   1. Description:
      a. Standard: MSS SP-80, Type 3.
      b. CWP Rating: 200 psig.

c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded or soldered. See valve schedule articles.
f. Disc: Bronze.

B. Bronze, Swing Check Valves with Nonmetallic Disc, Class 125:
1. Description:
a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded or soldered. See valve schedule articles.
f. Disc: PTFE.

C. Bronze, Swing Check Valves with Bronze Disc, Class 150:
1. Description:
a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 300 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded or soldered. See valve schedule articles.
f. Disc: Bronze.

D. Bronze, Swing Check Valves with Nonmetallic Disc, Class 150:
1. Description:
a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 300 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded or soldered. See valve schedule articles.
f. Disc: PTFE.

E. Bronze, Swing Check Valves, Press Ends:
1. Description:
a. Standard: MSS SP-80 and MSS SP-139.
b. CWP Rating: Minimum 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B584, bronze.
e. Ends: Press.
f. Press Ends Connection Rating: Minimum 200 psig
g. Disc: Brass or bronze.

PART 3 - EXECUTION

3.01 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. Examine press fittings to verify they have been properly press.

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

3.02 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.

D. Install valves so that stems are horizontal or slope upward from centerline of pipe.

E. Install valves in position that does not project into aisles or block access to other equipment.

F. Install valves in position to allow full stem and manual operator movement.

G. Verify that joints of each valve have been properly installed and sealed to assure there is no leakage or damage.

H. Check Valves: Install check valves for proper direction of flow.

1. Swing Check Valves: In horizontal position with hinge pin level.

I. Adhere to manufacturer's installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's recommended maximum.

3.03 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.

3.04 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

3.05 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze, swing check valves with bronze disc, Class 125, with threaded end connections.
2. Bronze, swing check valves with press-end connections.

B. Pipe NPS 2-1/2 and Larger:

1. Iron, swing check valves with nonmetallic-to-metal seats, Class 125, with threaded end connections.

END OF SECTION

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SECTION 220529
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Metal pipe hangers and supports.
   2. Fastener systems.
   3. Equipment supports.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
   1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
   2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

B. Related Requirements:
   1. The Read Mountain Fire Department and E-911 fire station building is a Risk Category IV facility with seismic importance factor 1.5. A Delegated Design Submittal is required to ensure that all systems and equipment are installed with the appropriate Seismic Controls in accordance with Standard ASCE 7-22, Chapter 13 – Seismic Design for Nonstructural Components. Engage a qualified Professional Engineer licensed in the Commonwealth of Virginia to design the seismic control system.
   2. Seismic Design Submittal is to include:
      a. Seismic Design Calculations used to properly select seismic-restraint devices, fasteners, and anchorage.
      b. Equipment manufacturer's written certification for each designated seismic device and system, stating that the protected system will remain operable following the design earthquake.
   3. Engage a factory-authorized service representative to perform tests and inspect components, assemblies, and equipment installations, including connections.
   4. Prepare test and inspection reports after removal and replacement of any malfunctioning devices and successful retesting.

2.02 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
   3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping and prevent corrosion of dissimilar metals.
   5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.03 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Indoor Applications: Zinc-coated.
2. Outdoor Applications: Stainless steel.

2.04 EQUIPMENT SUPPORTS

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

2.05 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.01 APPLICATION

A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.

B. 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.

3.02 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

C. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

D. Install hangers and supports to allow controlled thermal and seismic 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.

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

F. 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.

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

H. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

I. Insulated Piping:
   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 allowed by ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   3. 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 and larger if pipe is installed on rollers.
   4. Shield Dimensions for Pipe: Not less than the following:
      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.
      d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
      e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
   5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
   6. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.03 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 bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.04 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for 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/D1.1M 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 so contours of welded surfaces match adjacent contours.

3.05 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.

3.06 PAINTING

A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those 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 a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.07 HANGER AND SUPPORT SCHEDULE

A. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.

B. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

C. Use carbon-steel pipe hangers and supports attachments for general service applications.

D. 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 up to 1050 deg F pipes NPS 4 to NPS 24, 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 36, 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 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. 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 or carbon-steel plate.

15. 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 or carbon-steel plate, and with U-bolt to retain pipe.
16. 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.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction occurs.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction occurs.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction occurs but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction occurs and vertical adjustment is unnecessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation, in addition to expansion and contraction, is required.

E. 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 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

F. 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 of up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F 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 piping installations.

G. 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.
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.
    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.

H. 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.

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

END OF SECTION

SECTION 220553
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Pipe labels.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS

A. Plastic Labels for Equipment:
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
   2. Letter Color: White.
   3. Background 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 2-1/2 by 3/4 inch.
   6. 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-quarters the size of principal lettering.
   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 Drawing designation or unique equipment number.

2.02 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Services to be labeled include:
   1. Cold Water.
   2. Hot Water.
   3. Hot Water Recirculation.
   4. Natural Gas.
   5. Sanitary Waste.
   6. Sanitary Vent.
   7. Storm Water.
   8. Storm Water Overflow.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include 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.
2. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

PART 3 - EXECUTION

3.01 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.

3.02 GENERAL INSTALLATION REQUIREMENTS

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.

3.03 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.04 PIPE LABEL INSTALLATION

A. Pipe Label Locations: 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 fixtures and 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 along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
   7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

C. Pipe Label Color Schedule:
   1. Domestic Water Piping
      a. Background: Safety green.
      b. Letter Colors: White.
   2. Sanitary Waste and Storm Drainage Piping:
      a. Background Color: Safety gray.
      b. Letter Color: Black.

END OF SECTION

SECTION 220719
PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes insulating the following plumbing piping services:
   1. Domestic cold-water piping.
   2. Domestic hot-water piping.
   3. Domestic recirculating hot-water piping.
   4. Roof drains and rainwater leaders.
   5. Supplies and drains for handicap-accessible lavatories and sinks.

B. Related Sections:
   1. Section 220716 "Plumbing Equipment Insulation."

1.03 ACTION SUBMITTALS

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

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing 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 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.

C. Comply with the following applicable standards and other requirements specified for miscellaneous components:
   1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.05 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.

1.06 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping 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.

1.07 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

2.01 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

F. Mineral-Fiber, Preformed Pipe Insulation:

1. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.02 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.03 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: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

2.04 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
   1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F.
   3. Solids Content: 60 percent by volume and 66 percent by weight.
   4. Color: White.

2.05 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
   1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
   3. Service Temperature Range: 0 to plus 180 deg F.
   4. Color: White.

2.06 SEALANTS

A. Joint Sealants for Cellular-Glass and Phenolic Products:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Permanently flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 100 to plus 300 deg F.
   4. Color: White or gray.

B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F.
   4. Color: White.

2.07 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
   1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
   2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.08 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

2.09 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 11.5 mils.
   3. Adhesion: 90 ounces force/inch in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.10 SECUREMENTS

A. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

B. Wire: 0.080-inch nickel-copper alloy.

2.11 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers,:

1. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

B. Protective Shielding Piping Enclosures,:

1. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.02 PREPARATION

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

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

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

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

3.03 GENERAL INSTALLATION REQUIREMENTS

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

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of 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. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
G. Keep insulation materials dry during application and finishing.
H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
I. Install insulation with least number of joints practical.
J. 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 to tightly join 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.
K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
L. Install insulation with 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 o.c.
    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**] [**4 inches**] o.c.
        a. For below-ambient services, apply vapor-barrier mastic over staples.
    4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, 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.
M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
O. 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.
P. 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.
    4. Cleanouts.

3.04 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
   4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. 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. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

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 Section 078413 "Penetration Firestopping" for 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 Section 078413 "Penetration Firestopping."

3.05 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more 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, flanges, unions, 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. Butt 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. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
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.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. 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.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches

over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.06 INSTALLATION OF CELLULAR-GLASS INSULATION

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. Instead, 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.

3.07 INSTALLATION OF MINERAL-FIBER INSULATION

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. Instead, 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 mineral-fiber 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.

3.08 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.
   1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.09 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. Drainage piping located in crawl spaces.
   2. Underground piping.
   3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.10 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:
   1. NPS 1 and Smaller: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
   2. NPS 1-1/4 and Larger: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Domestic Hot and Recirculated Hot Water:
   1. NPS 1-1/4 and Smaller: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
C. Stormwater and Overflow:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
D. Roof Drain and Overflow Drain Bodies:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Cellular Glass: 1-1/2 inches thick.
      b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
E. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.

3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
B. If more than one material is listed, selection from materials listed is Contractor's option.
C. Piping, Concealed:
   1. ASJ to match factory jacket and form a complete jackets system.
D. Piping, Exposed:
   1. None.

END OF SECTION

SECTION 221113 - FACILITY WATER DISTRIBUTION PIPING

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 water-distribution piping and related components outside the building for water service.

B. Utility-furnished products include water meters that will be furnished to the site, ready for installation.

1.3 DEFINITIONS

A. PE: Polyethylene plastic.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.

B. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

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 ASTM F 645 for selection, design, and installation of thermoplastic water piping.

E. NSF Compliance:

1. Comply with NSF 14 for plastic potable-water-service piping.
2. Comply with NSF 61 for materials for water-service piping and specialties for domestic water.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:

1. Ensure that valves are dry and internally protected against rust and corrosion.
2. Protect valves against damage to threaded ends and flange faces.
3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. During Storage: Use precautions for valves, including fire hydrants, according to the following:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

D. Deliver piping 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.

E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect flanges, fittings, and specialties from moisture and dirt.

G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.8 PROJECT CONDITIONS

A. Interruption of Existing Water-Distribution 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 water-distribution service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of water-distribution service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PE PIPE AND FITTINGS

A. PE, ASTM Pipe: ASTM D 2239, SIDR No. 5.3, 7, or 9; with PE compound number required to give pressure rating not less than 200 psig.

1. Insert Fittings for PE Pipe: ASTM D 2609, made of PA, PP, or PVC with serrated male insert ends matching inside of pipe. Include bands or crimp rings.
2. Molded PE Fittings: ASTM D 3350, PE resin, socket- or butt-fusion type, made to match PE pipe dimensions and class.

2.2 COPPER TUBE AND FITTINGS

A. Soft Copper Tube: ASTM B 88, Type K, water tube, annealed temper.

1. Fittings: In accordance with ASTM B-62.

2.3 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.

2.4 JOINING MATERIALS

A. Plastic Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

2.5 PIPING SPECIALTIES

A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.6 GATE VALVES

A. AWWA, Cast-Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Cast Iron Pipe Co.; American Flow Control Div.
   b. Crane Co.; Crane Valve Group; Stockham Div.
   c. East Jordan Iron Works, Inc.
   d. McWane, Inc.
   e. Mueller Co.; Water Products Div.
   f. NIBCO INC.
   g. U.S. Pipe and Foundry Company.

2. Nonrising-Stem, Resilient-Seated Gate Valves:

   a. Description: Gray- or ductile-iron body and bonnet; with bronze or gray- or ductile-iron gate, resilient seats, bronze stem, and stem nut.

      1) Standard: AWWA C509.
      2) Minimum Pressure Rating: 200 psig.
      3) End Connections: Mechanical joint.
      4) Interior Coating: Complying with AWWA C550.

2.7 GATE VALVE ACCESSORIES AND SPECIALTIES

A. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, adjustable extension of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over valve. Operating wrenches shall be steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.

B. Indicator Posts: UL 789, FMG-approved, vertical-type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of burial of valve.

2.8 CURB VALVES

A. Manufacturers:

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

   a. Amcast Industrial Corporation; Lee Brass Co.
   b. Ford Meter Box Company, Inc. (The); Pipe Products Div.

c. Jones, James Company.
d. Master Meter, Inc.
e. McDonald, A. Y. Mfg. Co.
f. Mueller Co.; Water Products Div.
g. Red Hed Manufacturing & Supply.

B. Curb Valves: Comply with AWWA C800. Include bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.

C. Service Boxes for Curb Valves: Similar to AWWA M44 requirements for cast-iron valve boxes. Include cast-iron telescoping top section of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over curb valve and with a barrel approximately 5 inches in diameter.

1. Shutoff Rods: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve.

2.9 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Wilkins model 975XL2 or a comparable product by one of the following:

a. Ames Fire & Waterworks; a division of Watts Regulator Co.
b. FEBCO; SPX Valves & Controls.
c. Watts Water Technologies, Inc.
d. Wilkins; a Zurn company.

2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 15 psig maximum, through middle 1/3 of flow range.
5. Size: As indicated on drawings.
6. Configuration: Designed for horizontal, straight through flow.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Refer to Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. General: Use pipe, fittings, and joining methods for piping systems according to the Drawings.

B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

C. Do not use flanges or unions for underground piping.

3.3 VALVE APPLICATIONS

A. General Application: Use mechanical-joint-end valves for NPS 3 and larger underground installation. Use threaded- or flanged-end valves for installation in vaults. Use UL/FMG, nonrising-stem gate valves for installation with indicator posts. Use corporation valves and curb valves with ends compatible with piping, for NPS 2 and smaller installation.

3.4 PIPING INSTALLATION

A. Water-Main Connection: Arrange with utility company for tap of size and in location indicated in water main.

B. Install PE pipe according to ASTM D 2774 and ASTM F 645.

C. Bury piping with depth of cover over top in accordance with the Drawings.

D. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.

E. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.

1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.

F. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.

G. See Section 221116 "Domestic Water Piping" for potable-water piping inside the building.

3.5 JOINT CONSTRUCTION

A. Make pipe joints according to the following:

1. PE Piping Insert-Fitting Joints: Use plastic insert fittings and fasteners according to fitting manufacturer's written instructions.

B. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:

1. Concrete thrust blocks.
2. Locking mechanical joints.
3. Set-screw mechanical retainer glands.
4. Bolted flanged joints.
5. Heat-fused joints.
6. Pipe clamps and tie rods.

C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.6 VALVE INSTALLATION

A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

B. UL/FMG, Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.

C. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.

3.7 FIELD QUALITY CONTROL

A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.

B. Hydrostatic Tests: In accordance with VDOT Road and Bridge Specification Section 520.04.

C. Prepare reports of testing activities.

3.8 IDENTIFICATION

A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Section 312000 "Earth Moving."

3.9 CLEANING

A. Clean and disinfect water-distribution piping as follows:

1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
3. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:

    a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.

b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.
c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.

B. Prepare reports of purging and disinfecting activities.

END OF SECTION 221113

SECTION 221116
DOMESTIC WATER PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Under-building-slab and aboveground domestic water pipes, tubes, and fittings inside buildings.

1.03 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14 and NSF 61 Annex G.

2.02 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.

B. Soft Copper Tube: ASTM B 88, Type L water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Copper Unions:
   1. MSS SP-123.
   2. Cast-copper-alloy, hexagonal-stock body.
   3. Ball-and-socket, metal-to-metal seating surfaces.
   4. Solder-joint or threaded ends.

2.03 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe:
   1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Standard-Pattern, Mechanical-Joint Fittings:
   1. AWWA C110/A21.10, ductile or gray iron.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Compact-Pattern, Mechanical-Joint Fittings:
   1. AWWA C153/A21.53, ductile iron.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

D. Push-on-Joint, Ductile-Iron Pipe:
   1. AWWA C151/A21.51.

2. Push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.

E. Standard-Pattern, Push-on-Joint Fittings:
1. AWWA C110/A21.10, ductile or gray iron.
2. Gaskets: AWWA C111/A21.11, rubber.

F. Plain-End, Ductile-Iron Pipe: AWWA C151/A21.51.

2.04 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:
1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys.

D. Flux: ASTM B 813, water flushable.

2.05 TRANSITION FITTINGS

A. General Requirements:
1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

D. Dielectric Unions:
1. Standard: ASSE 1079.
2. Pressure Rating: 125 psig minimum at 180 deg F.
3. End Connections: Solder-joint copper alloy and threaded ferrous.

E. Dielectric Flanges:
1. Standard: ASSE 1079.
2. Factory-fabricated, bolted, companion-flange assembly.
3. Pressure Rating: 125 psig minimum at 180 deg F.
4. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

F. Dielectric-Flange Insulating Kits:
1. Nonconducting materials for field assembly of companion flanges.
2. Pressure Rating: 150 psig.
3. Gasket: Neoprene or phenolic.
4. Bolt Sleeves: Phenolic or polyethylene.
5. Washers: Phenolic with steel backing washers.

G. Dielectric Nipples:
1. Standard: IAPMO PS 66.
2. Electroplated steel nipple complying with ASTM F 1545.
3. Pressure Rating and Temperature: 300 psig at 225 deg F.
4. End Connections: Male threaded or grooved.
5. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.01 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.02 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install underground copper tube and ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105/A21.5.

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. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties."

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 221119 "Domestic Water Piping Specialties."

H. Install domestic water piping level without pitch and plumb.

I. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

J. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

K. 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.

L. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

M. Install piping to permit valve servicing.

N. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

O. Install piping free of sags and bends.

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

Q. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

R. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping."

S. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 221123 "Domestic Water Pumps."

T. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 220519 "Meters and Gages for Plumbing Piping."

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.03 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 pipes, tubes, 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.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

F. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

G. Push-on Joints for Copper Tubing: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Join copper tube and push-on-joint fittings by inserting tube to measured depth.

H. 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.

I. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.

J. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

K. Joint Construction for Solvent-Cemented Plastic Piping: 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. Apply primer.
   2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   3. PVC Piping: Join according to ASTM D 2855.

L. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.04 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
   1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
   2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

3.05 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings, unions, or nipples.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

3.06 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
   1. Vertical Piping: MSS Type 8 or 42, clamps.
   2. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support vertical piping and tubing at base and at each floor.

C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

D. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
   2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
   3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   4. NPS 2-1/2: 108 inches with 1/2-inch rod.
   5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
   6. NPS 6: 10 feet with 5/8-inch rod.
   7. NPS 8: 10 feet with 3/4-inch rod.

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

F. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
   7. NPS 6: 12 feet with 3/4-inch rod.
   8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

G. Install supports for vertical steel piping every 15 feet.

3.07 CONNECTIONS

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

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
3. Equipment: Cold- and hot-water-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.

3.08 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

3.09 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:
   a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
   b. During installation, notify authorities having jurisdiction at least one day 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 authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
   c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
   d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
2. Piping Tests:
   a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
   b. 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 a separate report for each test, complete with diagram of portion of piping tested.
   c. 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.
   d. 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 it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.

f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

3.10 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 hot-water flow in each branch.
   b. Adjust calibrated balancing valves to flows indicated.
5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
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.

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
   b. Fill and isolate system according to either of the following:
      1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
      2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
   c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
   d. Repeat procedures if biological examination shows contamination.
   e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

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 and unions may be used for aboveground piping joints unless otherwise indicated.

C. Under-building-slab, domestic water, building-service piping, NPS 3 and smaller, shall be the following:

1. Soft copper tube, ASTM B 88, Type L]; wrought-copper, solder-joint fittings; and brazed joints.

D. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 and larger, shall be one of the following:

1. Soft copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and brazed joints.
2. Mechanical-joint, ductile-iron pipe; standard-pattern, mechanical-joint fittings; and mechanical joints.

E. Under-building-slab, combined domestic water, building-service, and fire-service-main piping, NPS 6 to NPS 12, shall be one of the following:

1. Mechanical-joint, ductile-iron pipe; standard-pattern, mechanical-joint fittings; and mechanical joints.
2. Push-on-joint, ductile-iron pipe; standard-pattern, push-on-joint fittings; and gasketed joints.

F. Aboveground domestic water piping, NPS 2 and smaller, shall be the following:

1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.

G. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be the following:

1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.

3.13 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
3. Hot-Water Circulation Piping, Balancing Duty: Calibrated balancing valves.
4. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION

SECTION 221119
DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Vacuum breakers.
   2. Backflow preventers.
   3. Water pressure-reducing valves.
   4. Temperature-actuated, water mixing valves.
   5. Strainers for domestic water piping.
   6. Outlet boxes.
   7. Hose bibbs.
   8. Wall hydrants.
   9. Water-hammer arresters.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.
B. Shop Drawings: For domestic water piping specialties.

1.03 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Domestic water piping specialties intended to convey or dispense water for human consumption are to comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or to be certified in compliance with NSF 61 and NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.02 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.03 VACUUM BREAKERS

A. Hose-Connection Vacuum Breakers:
   1. Standard: ASSE 1011.
   2. Body: Bronze, nonremovable, with manual drain.
   3. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
B. Pressure Vacuum Breakers:
   1. Standard: ASSE 1020.
   2. Operation: Continuous-pressure applications.

2.04 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:
   1. Standard: ASSE 1012.
   2. Operation: Continuous-pressure applications.
   3. Size: NPS 3/4.
   4. Body: Bronze.
   5. End Connections: Union, solder joint.
   6. Finish: Rough bronze.
B. Reduced-Pressure-Principle Backflow Preventers as indicated on drawings:
   1. Standard: ASSE 1013.
   2. Operation: Continuous-pressure applications.

3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Configuration: Designed for horizontal, straight-through flow.
5. Accessories:
   a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
   b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
   c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

2.05 WATER PRESSURE-REDUCING VALVES

A. Water Regulators as indicated on drawings>:
1. Standard: ASSE 1003.
2. Pressure Rating: Initial working pressure of 150 psig.
3. End Connections: Threaded or solder for NPS 2 and smaller; flanged or solder for NPS 2-1/2 and NPS 3.

2.06 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices as indicated on drawings:
1. Standard: ASSE 1070.
2. Pressure Rating: 125 psig.
3. Type: Thermostatically controlled, water mixing valve.
4. Material: Bronze body with corrosion-resistant interior components.
5. Connections: Threaded union inlets and outlet.
6. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
7. Valve Finish: Chrome plated.

B. Primary, Thermostatic, Water Mixing Valves as indicated on drawings:
1. Standard: ASSE 1017.
2. Pressure Rating: 125 psig minimum unless otherwise indicated.
3. Type: Exposed-mounted, thermostatically controlled, water mixing valve.
4. Material: Bronze body with corrosion-resistant interior components.
5. Connections: Threaded union inlets and outlet.
6. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
7. Valve Finish: Chrome plated.

2.07 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 that complies with AWWA C550 or that is FDA approved, epoxy coated 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.
   b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
6. Drain: Factory-installed, hose-end drain valve.

2.08 OUTLET BOXES

A. Icemaker Outlet Boxes <Insert drawing designation if any>:
1. Mounting: Recessed. Fire rated.
2. Material and Finish: Enameled-steel or epoxy-painted-steel box and faceplate.

3. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
4. Accessory: Water hammer arrestor.
5. Supply Shutoff Fitting: NPS 1/2 gate, globe, or ball valve and NPS 1/2 copper, water tubing.

2.09 HOSE BIBBS

A. Hose Bibbs:
1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig.
7. Vacuum Breaker: Integral or field-installation, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Finished Rooms: Chrome or nickel plated.
10. Operation for Equipment Rooms: Wheel handle or operating key.
11. Operation for Service Areas: Wheel handle.
12. Operation for Finished Rooms: Operating key.
13. Include operating key with each operating-key hose bibb.
14. Include wall flange with each chrome- or nickel-plated hose bibb.

2.10 WALL HYDRANTS

A. Nonfreeze Wall Hydrants <Insert drawing designation if any>:
1. Standard: ASME A112.21.3M for self-draining wall hydrants.
2. Pressure Rating: 125 psig.
3. Operation: Loose key.
4. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
5. Inlet: NPS 3/4 or NPS 1.
6. Outlet, Concealed: With integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
7. Box: Deep, flush mounted with cover.
8. Box and Cover Finish: Polished nickel bronze.
9. Outlet, Exposed: With integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
10. Nozzle and Wall-Plate Finish: Polished nickel bronze.
11. Operating Keys: **One** with each wall hydrant.

2.11 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:
1. Standard: ASSE 1010 or PDI-WH 201.
2. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

PART 3 - EXECUTION

3.01 INSTALLATION OF PIPING SPECIALTIES

A. Backflow Preventers: Install in each water supply to 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-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
3. Do not install bypass piping around backflow preventers.

B. Temperature-Actuated, Water Mixing Valves: Install with check stops or shutoff valves on inlets and with shutoff valve on outlet.

C. Y-Pattern Strainers: For water, install on supply side of each water pressure-reducing valve.

D. Outlet Boxes: Install boxes recessed in wall or surface mounted on wall. Install 1-1/2-by-3-1/2-inch fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 061000 "Rough Carpentry."

E. Water-Hammer Arresters: Install in water piping in accordance with PDI-WH 201.

F. Trap-Seal Primer Systems: Install with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.02 PIPING CONNECTIONS

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

B. When installing piping specialties adjacent to equipment and machines, allow space for service and maintenance.

3.03 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

3.04 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.

D. Adjust each reduced-pressure-principle backflow preventer in accordance with manufacturer's written instructions, authorities having jurisdiction and the device's reference standard.

3.05 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
1. Test each reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION

SECTION 221313 - FACILITY SANITARY SEWERS

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:

1. Pipe and fittings.
2. Nonpressure and pressure couplings.
3. Cleanouts.
4. Manholes.

1.3 ACTION SUBMITTALS

A. Product Data: For pipe and fittings.

B. Shop Drawings: For manholes. Include plans, elevations, sections, details, and frames and covers.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic manholes, pipe, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle manholes according to manufacturer's written rigging instructions.

PART 2 - PRODUCTS

2.1 PVC PIPE AND FITTINGS

A. PVC Gravity Sewer Piping:

1. Pipe: ASTM D 3034, PVC sewer pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM D 3034, PVC with bell ends.
3. Gaskets: ASTM F 477, elastomeric seals.

2.2 CLEANOUTS

A. PVC Cleanouts:

1. Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

2.3 MANHOLES

A. Standard Precast Concrete Manholes:

1. Description: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Diameter: 48 inches minimum unless otherwise indicated.
3. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
4. Base Section: 8-inch minimum thickness for floor slab and 5-inch minimum thickness for walls and base riser section; with separate base slab or base section with integral floor.
5. Riser Sections: 5-inch minimum thickness, of length to provide depth indicated.
6. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
7. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
8. Steps: In accordance with Virginia Department of Transportation Standard ST-1.
9. Grade Rings: Reinforced-concrete rings, 4- to 12-inch total thickness, with diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope.

B. Manhole Frames and Covers:

1. Description: Ferrous; 24-inch ID by 8-inch riser, with 5-inch minimum-width flange. Include indented top design with lettering cast into cover, using wording equivalent to "SANITARY SEWER."
2. Material: ASTM A-48M, Class 30S iron unless otherwise indicated.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground sanitary sewer piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

F. Install gravity-flow, nonpressure, drainage piping according to the following:

1. Install piping pitched down in direction of flow, at minimum slope of 1 percent unless otherwise indicated.
2. Install piping with 36-inch minimum cover.
3. Install PVC gravity sewer piping according to ASTM D 2321 and ASTM F 1668.

G. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure, drainage piping according to the following:

1. Join PVC gravity sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasket joints.

3.4 MANHOLE INSTALLATION

A. General: Install manholes complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections with sealants according to ASTM C 891.

C. Form continuous concrete channels and benches between inlets and outlet.

D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches above finished surface elsewhere unless otherwise indicated.

3.5 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318.

3.6 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts, and use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

1. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.

B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 24 by 24 by 6 inches deep. Set with tops 1 inch above surrounding grade.

C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

3.7 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping to building's sanitary building drains specified in Section 221316 "Sanitary Waste and Vent Piping."

B. Connect to oil/water separators specified in Section 221323 "Sanitary Waste Interceptors."

3.8 IDENTIFICATION

A. Comply with requirements in Section 31200 "Earth Moving" for underground utility identification devices. Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.

1. Use detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.9 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Submit separate report for each system inspection.
2. Defects requiring correction include the following:

    a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    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. Damage: Crushed, broken, cracked, or otherwise damaged piping.
    d. Infiltration: Water leakage into piping.
    e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:

    a. Fill sewer piping with water. Test with pressure of at least 10-foot head of water, and maintain such pressure without leakage for at least 15 minutes.
    b. Close openings in system and fill with water.
    c. Purge air and refill with water.
    d. Disconnect water supply.
    e. Test and inspect joints for leaks.

6. Air Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

    a. Option: Test plastic gravity sewer piping according to ASTM F 1417.

7. Manholes: Perform hydraulic test according to ASTM C 969.

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.10 CLEANING

A. Clean dirt and superfluous material from interior of piping.

END OF SECTION 221313

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SECTION 221316
SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Hubless, cast-iron soil pipe and fittings.
   2. PVC pipe and fittings.
   3. Specialty pipe fittings.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.04 FIELD CONDITIONS

A. Interruption of Existing Sanitary Waste 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 Owner no fewer than two days in advance of proposed interruption of sanitary waste service.
   2. Do not proceed with interruption of sanitary waste service without Owner's written permission.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
   1. Soil, Waste, and Vent Piping: 10-foot head of water.

2.02 PIPING MATERIALS

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.03 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. CISPI, Hubless-Piping Couplings:
   1. Standards: ASTM C 1277 and CISPI 310.
   2. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.04 PVC PIPE AND FITTINGS

A. 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 and "NSF-sewer" for plastic sewer piping.

B. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

D. Adhesive Primer: ASTM F 656.

E. Solvent Cement: ASTM D 2564.

2.05 SPECIALTY PIPE FITTINGS

A. Transition Couplings:
   1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

2. Unshielded, Nonpressure Transition Couplings:
   a. Standard: ASTM C 1173.
   b. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
   c. End Connections: Same size as and compatible with pipes to be joined.
   d. Sleeve Materials:
      1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
      2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
      3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
3. Shielded, Nonpressure Transition Couplings:
   a. Standard: ASTM C 1460.
   b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
   c. End Connections: Same size as and compatible with pipes to be joined.

PART 3 - EXECUTION

3.01 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.02 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
   1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
   2. 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. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.
   1. 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.
   2. 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 drain pipe.
      a. Straight tees, elbows, and crosses may be used on vent lines.
   3. Do not change direction of flow more than 90 degrees.
   4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.

a. Reducing size of waste piping in direction of flow is prohibited.

K. Lay buried building waste piping beginning at low point of each system.
1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

L. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:
1. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

M. Install aboveground PVC piping according to ASTM D 2665.

N. Install underground PVC piping according to ASTM D 2321.

O. Install engineered soil and waste and vent piping systems as follows:
1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
2. Hubless, Single-Stack Drainage System: Comply with ASME B16.45 and hubless, single-stack aerator fitting manufacturer's written installation instructions.
3. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

P. Plumbing Specialties:
1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.
a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.

Q. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

R. Install sleeves for piping penetrations of walls, ceilings, and floors.
1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

S. Install sleeve seals for piping penetrations of concrete walls and slabs.
1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

T. Install escutcheons for piping penetrations of walls, ceilings, and floors.
1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.03 JOINT CONSTRUCTION

A. Plastic, Nonpressure-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 Piping: Join according to ASTM D 2855 and ASTM D 2665 appendixes.

3.04 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
1. Install transition couplings at joints of piping with small differences in ODs.
2. In Waste Drainage Piping: Unshielded, nonpressure transition couplings.

3.05 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.

2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
3. Vertical Piping: MSS Type 8 or Type 42, clamps.
4. Install individual, straight, horizontal piping runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
6. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Install hangers for cast-iron soil piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Install hangers for PVC piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

E. Support vertical runs of cast iron soil piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Support vertical runs of PVC piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.06 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 waste and vent piping to the following:
1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

3.07 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.

B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.08 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 waste 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.
        a. 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 waste and vent piping until it has been tested and approved.
        a. Expose work that was covered or concealed before it was tested.
    3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.
        a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
        b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
        c. 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.
        a. 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.
        b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
        c. Air pressure must remain constant without introducing additional air throughout period of inspection.
        d. 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.

3.09 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.
B. Protect sanitary waste and vent piping 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.
D. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.
E. Repair damage to adjacent materials caused by waste and vent piping installation.

3.10 PIPING SCHEDULE

A. Aboveground, soil and waste piping NPS 6 and smaller that is installed within air plenum spaces or exposed to view in an occupied area below shall be the following:
    1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints suitable for air plenum installation locations.
    2. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.
B. Aboveground, soil and waste piping NPS 6 and smaller that is concealed shall be the following:
    1. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

2. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

C. Aboveground, vent piping NPS 4 and smaller that is installed within air plenum spaces or exposed to view in an occupied area below shall be the following:
   1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints suitable for air plenum installation locations.
   2. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

D. Aboveground, vent piping NPS 4 and smaller that is concealed shall be the following:
   1. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
   2. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

E. Underground, soil, waste, and vent piping NPS 6 and smaller shall be the following:
   1. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION

SECTION 221414
STORM DRAINAGE PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. PVC pipe and fittings.
   2. Hubless, cast-iron soil pipe and fittings.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
   1. Storm Drainage Piping: 10-foot head of water.

2.02 PVC PIPE AND FITTINGS

A. NSF Marking: Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic storm drain and "NSF-sewer" for plastic storm sewer piping.
B. Solid-Wall PVC Pipe: ASTM D 2665; drain, waste, and vent.
C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
D. Adhesive Primer: ASTM F 656.
E. Solvent Cement: ASTM D 2564.
F. 2.3 HUBLESS, CAST IRON SOIL PIPE AND FITTINGS
G. Pipe and Fittings: ASTM A 88 or CISPI 301.
H. CISPI, Hubless-Piping Couplings:
   1. Standards: ASTM C 1277 and CISPI 310.
   2. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

PART 3 - EXECUTION

3.01 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.02 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
   1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
   2. Install piping as indicated unless deviations from 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. Make changes in direction for piping using appropriate branches, bends, and long-sweep bends.
    1. Do not change direction of flow more than 90 degrees.
    2. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
        a. Reducing size of drainage piping in direction of flow is prohibited.
K. Lay buried building piping beginning at low point of each system.
    1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
    2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
    3. Maintain swab in piping and pull past each joint as completed.
L. Install aboveground PVC piping according to ASTM D 2665.
M. Install underground PVC piping according to ASTM D 2321.
N. Plumbing Specialties:
    1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping.
        a. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.
        b. Comply with requirements for cleanouts specified in Section 221423 "Storm Drainage Piping Specialties."
    2. Install drains in storm drainage gravity-flow piping.
        a. Comply with requirements for drains specified in Section 221423 "Storm Drainage Piping Specialties."
O. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
P. Install sleeves for piping penetrations of walls, ceilings, and floors.
    1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
Q. Install sleeve seals for piping penetrations of concrete walls and slabs.
    1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
R. Install escutcheons for piping penetrations of walls, ceilings, and floors.
    1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.03 JOINT CONSTRUCTION

A. Plastic, Nonpressure-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. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 appendices.
B. Joint Restraints and Sway Bracing:
    1. Provide joint restraints and sway bracing for storm drainage piping joints to comply with the following conditions:

a. Provide axial restraint for pipe and fittings 5 inches and larger, upstream and downstream of all changes in direction, branches, and changes in diameter greater than two pipe sizes.
b. Provide rigid sway bracing for pipe and fittings 4 inches and larger, upstream and downstream of all changes in direction 45 degrees and greater.

3.04 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for hangers, supports, and anchor devices specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
3. Vertical Piping: MSS Type 8 or Type 42, clamps.
4. Install individual, straight, horizontal piping runs:
a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
6. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Install hangers for PVC piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

D. Support vertical runs of cast iron soil piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are more stringent.

E. Support vertical PVC piping with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.05 CONNECTIONS

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

B. Connect storm drainage piping to roof drains and storm drainage specialties.
1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
2. Comply with requirements for cleanouts and drains specified in Section 221423 "Storm Drainage Piping Specialties."

3.06 IDENTIFICATION

A. Identify exposed storm drainage piping.

B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.07 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.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Test storm drainage 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.

a. 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 storm drainage piping until it has been tested and approved.
   a. Expose work that was covered or concealed before it was tested.
3. Test Procedure:
   a. Test storm drainage piping on completion of roughing-in.
   b. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

C. Piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.08 CLEANING AND PROTECTION

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.

3.09 PIPING SCHEDULE

A. Above ground storm drainage piping NPS 14 and smaller that is installed within air plenum spaces shall be the following:
   1. Hubless cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints suitable for air plenum installation locations.
   2. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

B. Aboveground storm drainage piping NPS 14 and smaller that is NOT located in air plenum spaces may be the following:
   1. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

C. Underground storm drainage piping NPS 14 and smaller shall be the following:
   1. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

END OF SECTION

SECTION 223300
ELECTRIC, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Commercial, electric, domestic-water booster heaters.
2. Commercial, electric, storage, domestic-water heaters.
3. Commercial, light-duty, storage, electric, domestic-water heaters.
4. Residential, small-capacity, electric, domestic-water heaters.
5. Residential, collector-to-tank, solar, electric, domestic-water heaters.
6. Residential, collector-to-tank-coil, solar, electric, domestic-water heaters.
7. Residential, electric, storage, domestic-water heaters.
8. Residential, tabletop, electric, domestic-water heaters.
9. Flow-control, electric, tankless, domestic-water heaters.
10. Thermostat-control, electric, tankless, domestic-water heaters.
11. Domestic-water heater accessories.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:
1. <Double click to insert sustainable design text for water heaters.>

C. Shop Drawings:
1. Include diagrams for power, signal, and control wiring.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Equipment room drawing or BIM model, drawn to scale, on which the items described in this Section are shown and coordinated with all building trades.

B. Seismic Qualification Data: Certificates, for commercial domestic-water heaters, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
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.

C. Product Certificates: For each type of [**commercial**] [**residential**] [**and**] [**tankless**], electric, domestic-water heater.

D. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: For special warranty.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric, domestic-water heaters to include emergency, operation, and maintenance manuals.

1.05 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.06 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of electric, domestic-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 Periods: From date of Substantial Completion.
   a. Commercial, Electric, Domestic-Water Booster Heaters:
      1) Controls and Other Components: [**Three**] [**Five**] <**Insert number**> years.
   b. Commercial, Electric, Storage, Domestic-Water Heaters:
      1) Storage Tank: [**Three**] [**Five**] <**Insert number**> years.
      2) Controls and Other Components: [**Three**] [**Five**] <**Insert number**> years.
   c. Commercial, Light-Duty, Storage, Electric, Domestic-Water Heaters:
      1) Storage Tank: [**Three**] [**Five**] <**Insert number**> years.
      2) Controls and Other Components: [**Two**] [**Three**] <**Insert number**> years.
   d. Residential, Electric, Storage, Domestic-Water Heaters:
      1) Storage Tank: [**Five**] [**Six**] [**10**] <**Insert number**> years.
      2) Controls and Other Components: [**Two**] [**Three**] <**Insert number**> years.
   e. Electric, Tankless, Domestic-Water Heaters: [**One**] [**Two**] [**Five**] <**Insert number**> year(s).
   f. Expansion Tanks: [**Five**] <**Insert number**> years.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. Seismic Performance: Commercial, electric, domestic-water heaters to withstand the effects of earthquake motions determined in accordance with [**ASCE/SEI 7**] <**Insert requirement**>.

1. 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. Component Importance Factor: [**1.5**] [**1.0**].
3. <Insert requirements for Component Amplification Factor and Component Response Modification Factor>.

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

D. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.

2.02 COMMERCIAL, ELECTRIC, DOMESTIC-WATER HEATERS

A. Commercial, Electric, Domestic-Water Booster Heaters:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water booster heaters from single source from single manufacturer.
3. Standard: UL 1453.
4. Tank Construction: [Corrosion-resistant metal] [or] [steel].

a. Tappings: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig.
c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.

5. Factory-Installed Tank Appurtenances:
a. Anode Rod: Replaceable magnesium.
b. Drain Valve: Corrosion-resistant metal with hose-end connection.
c. Insulation: Comply with ASHRAE/IES 90.1.
d. Jacket: Rectangular shaped, with stainless steel front panel, unless otherwise indicated.
e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
1) Option: Booster heaters with total of 9 kW or less may have one, two, or three elements.
f. Temperature Control: Adjustable thermostat, to setting of at least 180 deg F.
g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
h. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valve. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.
i. Gauges: Combination temperature-and-pressure type or separate thermometer and pressure gauge.

6. Special Requirements: NSF 5 construction with [**brackets for undercounter**] [**legs for floor**] installation.

B. Commercial, Electric, Storage, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: UL 1453.
4. Storage-Tank Construction: [**Non-**]ASME-code, steel [**horizontal**] [**vertical**] arrangement.
a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.
1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges, and in accordance with ASME B16.24 for copper and copper-alloy flanges.
b. Pressure Rating: [**150 psig**] <Insert value>.
c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.

5. Factory-Installed, Storage-Tank Appurtenances:
a. Anode Rod: Replaceable magnesium.
b. Drain Valve: Corrosion-resistant metal with hose-end connection.
c. Insulation: Comply with ASHRAE/IES 90.1.
d. Jacket: Steel with enameled finish or high-impact composite material.
e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
f. Temperature Control: Adjustable thermostat.

g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
h. Relief Valves: ASME rated and stamped 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 working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

6. Special Requirements: NSF 5 construction.

C. Commercial, Light-Duty, Storage, Electric, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: UL 174.
4. Storage-Tank Construction: Steel, vertical arrangement.
a. Tappings: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig.
c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
5. Factory-Installed, Storage-Tank Appurtenances:
a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: Corrosion-resistant metal with hose-end connection.
d. Insulation: Comply with ASHRAE/IES 90.1.
e. Jacket: Steel with enameled finish or high-impact composite material.
f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
g. Heating Elements: Electric, screw-in immersion type.
h. Temperature Control: Adjustable thermostat.
i. Safety Control: High-temperature-limit cutoff device or system.
j. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.
6. Special Requirements: NSF 5 construction with legs for off-floor installation.

D. Capacity and Characteristics:
1. Capacity: <Insert **gal.** >.
2. Recovery: <Insert **gph**> at [**40 deg F**] [**50 deg F**] [**100 deg F**] <Insert temperature> temperature rise.
3. Temperature Setting: [**125 deg F**] [**140 deg F**] [**180 deg F**] <Insert temperature>.
4. Power Demand: <**Insert kilowatts**>.
5. Heating Elements:
a. Number of Elements: [**Two**] [**Three**] [**Six**] [**Nine**] <**Insert number**>.
b. Kilowatts Each Element: <**Insert kilowatts**>.
c. Number of Stages: [**One**] [**Two**] [**Three**] [**Four**] <**Insert number**>.
6. Electrical Characteristics:
a. Volts: [**120**] [**240**] [**277**] [**480**] <**Insert value**> V.
b. Phases: [**Single**] [**Three**].
c. Hertz: 60 Hz.
d. Full-Load Amperes: <**Insert value**> A.
e. Minimum Circuit Ampacity: <**Insert value**> A.
f. Maximum Overcurrent Protection: <**Insert value**> A.

2.03 RESIDENTIAL, ELECTRIC, DOMESTIC-WATER HEATERS

A. Residential, Small-Capacity, Electric, Domestic-Water Heaters:
   1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
   2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
   3. Standard: UL 174.
   4. Storage-Tank Construction: Corrosion-resistant metal[**or steel with corrosion-resistant coating**].
      a. Tappings: ASME B1.20.1 pipe thread.
      b. Pressure Rating: 150 psig.
      c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
   5. Factory-Installed, Storage-Tank Appurtenances:
      a. Drain Valve: Corrosion-resistant metal with hose-end connection if tank has drain outlet. Provide hose-end drain valve in piping for domestic-water heaters without drain outlet. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."
      b. Insulation: Comply with [**ASHRAE/IES 90.1**] [**ASHRAE 90.2**].
      c. Jacket: Steel with enameled finish or high-impact composite material.
      d. Heating Element: One; electric, screw-in immersion type.
      e. Temperature Control: Adjustable thermostat.
      f. Safety Control: High-temperature-limit cutoff device or system.
      g. Power Supply Cord: 24 to 72 inches with plug.
      h. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.

B. Residential, Collector-to-Tank, Solar, Electric, Domestic-Water Heaters:
   1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
   2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
   3. Standard: UL 174 with piping and electrical connections for UL 1279 solar collector system.
   4. Storage-Tank Construction: Steel.
      a. Tappings: ASME B1.20.1 pipe thread.
      b. Pressure Rating: 150 psig.
      c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
   5. Factory-Installed, Storage-Tank Appurtenances:
      a. Sensor electrical connections and tank stud for sensor.
      b. Anode Rod: Replaceable magnesium.
      c. Dip Tube: Required unless cold-water inlet is near bottom of tank.
      d. Drain Valve: Corrosion-resistant metal with hose-end connection.
      e. Insulation: Comply with [**ASHRAE/IES 90.1**] [**ASHRAE 90.2**].
      f. Jacket: Steel with enameled finish.
      g. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
      h. Heating Element: Electric, screw-in immersion type.
      i. Temperature Control: Adjustable thermostat.
      j. Safety Control: High-temperature-limit cutoff device or system.

k. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.

C. Residential, Collector-to-Tank-Coil, Solar, Electric, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: UL 174 with integral coil-type heat exchanger.
4. Storage-Tank Construction: Steel.
   a. Tappings: ASME B1.20.1 pipe thread.
   b. Pressure Rating: 150 psig.
   c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
5. Factory-Installed, Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.
   b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
   c. Drain Valve: Corrosion-resistant metal with hose-end connection.
   d. Insulation: Comply with [**ASHRAE/IES 90.1**] [**ASHRAE 90.2**].
   e. Jacket: Steel with enameled finish or high-impact composite material.
   f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
   g. Heat Exchanger: Corrosion-resistant-metal immersion coil.
   h. Heating Element: Electric, screw-in immersion type.
   i. Temperature Control: Adjustable thermostat.
   j. Safety Control: High-temperature-limit cutoff device or system.
   k. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.

D. Residential, Electric, Storage, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: UL 174.
4. Storage-Tank Construction: Steel.
   a. Tappings: ASME B1.20.1 pipe thread.
   b. Pressure Rating: 150 psig.
   c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
5. Factory-Installed, Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.
   b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
   c. Drain Valve: Corrosion-resistant metal with hose-end connection.
   d. Insulation: Comply with [**ASHRAE/IES 90.1**] [**ASHRAE 90.2**].
   e. Jacket: Steel, cylindrical, with enameled finish or high-impact composite material.
   f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
   g. Heating Elements: Electric, screw-in immersion type.
   h. Temperature Control: Adjustable thermostat.
   i. Safety Control: High-temperature-limit cutoff device or system.

j. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.

E. Residential, Tabletop, Electric, Domestic-Water Heaters:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: UL 174.
4. Storage-Tank Construction: Steel.
   a. Tappings: ASME B1.20.1 pipe thread.
   b. Pressure Rating: 150 psig.
   c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
5. Factory-Installed, Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.
   b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
   c. Drain Valve: Corrosion-resistant metal with hose-end connection.
   d. Insulation: Comply with [**ASHRAE/IES 90.1**] [**ASHRAE 90.2**].
   e. Jacket: Steel, rectangular, with flat-top work surface, raised back, and enameled finish.
   f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
   g. Heating Elements: Electric, screw-in immersion type.
   h. Temperature Control: Adjustable thermostat.
   i. Safety Control: High-temperature-limit cutoff device or system.
   j. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.

F. Capacity and Characteristics:

1. Capacity: <Insert **gal.** >.
2. Recovery: <Insert **gph**> at [**100 deg F**] <Insert temperature> temperature rise.
3. Temperature Setting: [**125 deg F**] <Insert temperature>.
4. Power Demand: <**Insert kilowatts**>.
5. Heating Elements: <**Insert kilowatts**>.
6. Electrical Characteristics:
   a. Volts: [**120**] [**240**] <**Insert value**> V.
   b. Phases: [**Single**] [**Three**].
   c. Hertz: 60 Hz.
   d. Full-Load Amperes: <**Insert value**> A.
   e. Minimum Circuit Ampacity: <**Insert value**> A.
   f. Maximum Overcurrent Protection: <**Insert value**> A.

2.04 ELECTRIC, TANKLESS, DOMESTIC-WATER HEATERS

A. Flow-Control, Electric, Tankless, Domestic-Water Heaters:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: UL 499 for electric, tankless, (domestic-water-heater) heating appliance.

4. Construction: Copper piping or tubing complying with NSF 61 and NSF 372 barrier materials for potable water, without storage capacity.
   a. Connections: ASME B1.20.1 pipe thread.
   b. Pressure Rating: [**150 psig**] <Insert value>.
   c. Heating Element: Resistance heating system.
   d. Temperature Control: Flow-control fitting.
   e. Safety Control: High-temperature-limit cutoff device or system.
   f. Jacket: Aluminum or steel with enameled finish or plastic.
5. Support: Bracket for wall mounting.
6. Capacity and Characteristics:
   a. Flow Rate: <Insert **gpm**>.
   b. Maximum Temperature Setting: <**Insert temperature**>.
   c. Power Demand: <**Insert kilowatts**>.
   d. Electrical Characteristics:
      1) Volts: [**120**] [**240**] [**277**] [**480**] <**Insert value**> V.
      2) Phases: [**Single**] [**Three**].
      3) Hertz: 60 Hz.
      4) Full-Load Amperes: <**Insert value**> A.
      5) Minimum Circuit Ampacity: <**Insert value**> A.
      6) Maximum Overcurrent Protection: <**Insert value**> A.

B. Thermostat-Control, Electric, Tankless, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: UL 499 for electric, tankless, (domestic-water-heater) heating appliance.
4. Construction: Copper piping or tubing complying with NSF 61 and NSF 372 barrier materials for potable water, without storage capacity.
   a. Connections: ASME B1.20.1 pipe thread.
   b. Pressure Rating: [**150 psig**] <Insert value>.
   c. Heating Element: Resistance heating system.
   d. Temperature Control: Thermostat.
   e. Safety Control: High-temperature-limit cutoff device or system.
   f. Jacket: Aluminum or steel with enameled finish or plastic.
5. Support: Bracket for wall mounting.
6. Capacity and Characteristics:
   a. Flow Rate: <Insert **gpm**> at [**100 deg F**] <Insert temperature> temperature rise.
   b. Temperature Setting: [**125 deg F**] [**140 deg F**] <Insert temperature>.
   c. Power Demand: <**Insert kilowatts**>.
   d. Electrical Characteristics:
      1) Volts: [**120**] [**240**] [**277**] [**480**] <**Insert value**> V.
      2) Phases: [**Single**] [**Three**].
      3) Hertz: 60 Hz.
      4) Full-Load Amperes: <**Insert value**> A.
      5) Minimum Circuit Ampacity: <**Insert value**> A.
      6) Maximum Overcurrent Protection: <**Insert value**> A.

2.05 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Expansion Tanks:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain domestic-water expansion tanks from single source from single manufacturer.
3. 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.
4. Construction:
   a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
   b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   c. Air-Charging Valve: Factory installed.
5. Capacity and Characteristics:
   a. Working-Pressure Rating: [**100 psig**] [**150 psig**] <Insert value>.
   b. Capacity Acceptable: [**2 gal.**] [**4 gal.**] [**7 gal.**] [**10 gal.**] <Insert value> minimum.
   c. Air Precharge Pressure: <**Insert system pressure**>.

B. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 with ASME B1.20.1 pipe threads.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement in accordance with [**ASHRAE/IES 90.1**] [**ASHRAE 90.2**].

D. Heat-Trap Fittings: [**ASHRAE/IES 90.1**] [**ASHRAE 90.2**].

E. Manifold Kits: Domestic-water-heater manufacturer's factory-fabricated inlet and outlet piping for field installation, for multiple domestic-water heater installation. Include ball-, butterfly-, or gate-type shutoff valves to isolate each domestic-water heater and [**calibrated**] [**memory-stop**] balancing valves to provide balanced flow through each domestic-water heater.
   1. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
   2. Comply with requirements for balancing valves specified in Section 221119 "Domestic Water Piping Specialties."

F. Pressure-Reducing Valves: ASSE 1003 for water. Set at 25-psig-maximum outlet pressure unless otherwise indicated.

G. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valves with sensing element that extends into storage tank.

H. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than working-pressure rating of domestic-water heater.

I. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.

J. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.

K. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Include dimension that will support bottom of domestic-water heater a minimum of [**18 inches**] <**Insert dimension**> above the floor.

L. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.06 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, in accordance with ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test[**commercial**] domestic-water heaters to minimum of one and one-half times pressure rating before shipment.

C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Electric, Domestic-Water Heater Mounting: Install commercial, electric, domestic-water heaters on concrete base. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete."

1. Exception: Omit concrete bases for commercial, electric, domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
2. Maintain manufacturer's recommended clearances.
3. Arrange units so controls and devices that require servicing are accessible.
4. 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 concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Install anchor bolts to elevations required for proper attachment to supported equipment.
8. Anchor domestic-water heaters to substrate.

B. Residential, Electric, Domestic-Water Heater Mounting: Install residential, electric, domestic-water heaters [**on floor**] [**on water-heater stand on floor**] [**on domestic-water heater mounting bracket**].

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
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. Anchor domestic-water heaters to substrate.

C. Electric, Tankless, Domestic-Water Heater Mounting: Install electric, tankless, domestic-water heaters[**at least 18 inches above floor**] on wall bracket.

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
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. Anchor domestic-water heaters to substrate.

D. Install electric, domestic-water heaters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's

recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."

E. Install commercial, electric, domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in [**Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."**] [**Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."**]

F. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-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.

G. Install [**combination temperature-and-**]pressure relief valves in water piping for electric, domestic-water heaters without storage. Extend domestic-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 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 electric, domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."

I. Install thermometers on outlet piping of electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."

J. Install thermometers on inlet and outlet piping of residential, solar, electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."

K. Assemble and install inlet and outlet piping manifold kits for multiple electric, domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each electric, domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each electric, domestic-water heater outlet. Comply with requirements for valves specified in Section 220523 "General-Duty Valves for Plumbing Piping" and comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."

L. Install pressure-reducing valve with integral bypass relief valve in electric, domestic-water booster-heater inlet piping and water hammer arrester in booster-heater outlet piping. Set pressure-reducing valve for outlet pressure of [**25 psig**] <**Insert value**>. Comply with requirements for pressure-reducing valves and water hammer arresters specified in Section 221119 "Domestic Water Piping Specialties."

M. Install piping-type heat traps on inlet and outlet piping of electric, domestic-water heater storage tanks without integral or fitting-type heat traps.

N. Fill electric, domestic-water heaters with water.

O. Charge domestic-water expansion tanks with air to required system pressure.

P. Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water to contain less than 0.25 percent of lead by weight.

3.02 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.03 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.04 FIELD QUALITY CONTROL

A. Testing Agency:
   1. Owner will engage a qualified testing agency to perform tests and inspections.
   2. Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections[with the assistance of a factory-authorized service representative].

D. 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 operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.05 DEMONSTRATION

A. [**Engage a factory-authorized service representative to train**] [**Train**] Owner's maintenance personnel to adjust, operate, and maintain [**commercial**] [**and**] [**tankless**], electric, domestic-water heaters. Training to be a minimum of [**one**] [**two**] <**Insert duration**> hour(s).

END OF SECTION

SECTION 223400
FUEL-FIRED, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Commercial, atmospheric, gas-fired, storage, domestic-water heaters.
2. Commercial, power-burner, gas-fired, storage, domestic-water heaters.
3. Commercial, power-vent, gas-fired, storage, domestic-water heaters.
4. Commercial, direct-vent, gas-fired, storage, domestic-water heater.
5. Commercial, gas-fired, high-efficiency, storage, domestic-water heaters.
6. Commercial, coil-type, finned-tube, gas-fired, domestic-water heaters.
7. Commercial, grid-type, finned-tube, gas-fired, domestic-water heaters.
8. Gas-fired, tankless, domestic-water heaters.
9. Residential, atmospheric, gas-fired, storage, domestic-water heaters.
10. Residential, direct-vent, gas-fired, storage, domestic-water heaters.
11. Residential, power-vent, gas-fired, storage, domestic-water heaters.
12. Commercial, oil-fired, storage, domestic-water heaters.
13. Commercial, large-volume, oil-fired, domestic-water heaters.
14. Residential, oil-fired, storage, domestic-water heaters.
15. Commercial, gas- and oil-fired, domestic-water heaters.
16. Domestic-water heater accessories.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.[Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.]

B. Sustainable Design Submittals:
1. <Double click to insert sustainable design text for water heaters.>

C. Shop Drawings:
1. Include diagrams for power, signal, and control wiring.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Equipment room drawing or BIM model, drawn to scale, on which the items described in this Section are shown and coordinated with all building trades.

B. Seismic Qualification Data: Certificates, for fuel-fired, domestic-water heaters, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
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.

C. Product Certificates: For each type of [commercial, gas-fired,] [gas-fired, tankless,] [residential, gas-fired,] [commercial, oil-fired,] [residential, oil-fired,] [and] [commercial, gas- and oil-fired,] domestic-water heater.

D. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: For special warranty.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuel-fired, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.05 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.06 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of fuel-fired, domestic-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 Periods: From date of Substantial Completion.
   a. Commercial, Gas-Fired, Storage, Domestic-Water Heaters:
      1) Storage Tank: [**Three**] [**Five**] <**Insert number**> years.
      2) Controls and Other Components: [**One**] [**Two**] <**Insert number**> year(s).
   b. Commercial, Finned-Tube, Gas-Fired, Domestic-Water Heaters:
      1) Heat Exchanger: [**Three**] [**Five**] <**Insert number**> years.
      2) Controls and Other Components: [**One**] [**Two**] <**Insert number**> year(s).
      3) Separate Hot-Water Storage Tanks: [**Three**] [**Five**] <**Insert number**> years.
   c. Gas-Fired, Tankless, Domestic-Water Heaters:
      1) Heat Exchanger: [**Five**] <**Insert number**> years.
      2) Controls and Other Components: [**Three**] <**Insert number**> years.
   d. Residential, Gas-Fired, Storage, Domestic-Water Heaters:
      1) Storage Tank: [**Five**] [**Six**] <**Insert number**> years.
      2) Controls and Other Components: [**Two**] [**Three**] <**Insert number**> years.
   e. Commercial, Oil-Fired, Domestic-Water Heaters:
      1) Storage Tank: [**Three**] [**Five**] <**Insert number**> years.
      2) Burner: [**One**] [**Two**] <**Insert number**> year(s).
      3) Controls and Other Components: [**One**] [**Two**] [**Three**] <**Insert number**> year(s).
   f. Residential, Oil-Fired, Storage, Domestic-Water Heaters:
      1) Storage Tank: [**Five**] [**Six**] <**Insert number**> years.
      2) Burner: [**One**] [**Two**] <**Insert number**> year(s).
      3) Controls and Other Components: [**Two**] [**Three**] <**Insert number**> years.
   g. Commercial, Gas- and Oil-Fired, Domestic-Water Heaters:
      1) Storage Tank: [**Three**] [**Five**] <**Insert number**> years.
      2) Burner: [**One**] [**Two**] <**Insert number**> year(s).
      3) Controls and Other Components: [**Two**] [**Three**] <**Insert number**> years.
   h. Expansion Tanks: [**Five**] <**Insert number**> years.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. Seismic Performance: Commercial domestic-water heaters shall withstand the effects of earthquake motions determined in accordance with [**ASCE/SEI 7**] <**Insert requirement**>.

1. 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. Component Importance Factor: [**1.5**] [**1.0**].
3. <Insert requirements for Component Amplification Factor and Component Response Modification Factor>.

C. ASHRAE/IES Compliance: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IES 90.1.
1. <Double click to insert sustainable design text for additional requirement for water efficiency.>

D. ASME Compliance:
1. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube, domestic-water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.

E. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.

2.02 COMMERCIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

A. Commercial, Atmospheric, Gas-Fired, Storage, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: ANSI Z21.10.3/CSA 4.3.
4. Storage-Tank Construction: [**Non-**]ASME-code steel with [**150-psig**] <**Insert value**> working-pressure rating.
   a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
      1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
      2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
   b. Interior Finish: Comply with NSF 61 and NSF 372 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**] <**Insert material**> complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
5. Factory-Installed, Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.
   b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
   c. Drain Valve: Corrosion-resistant metal with hose-end connection.
   d. Insulation: Comply with ASHRAE/IES 90.1. Surround entire storage tank except connections and controls.
   e. Jacket: Steel with enameled finish.

f. Burner: For use with atmospheric, gas-fired, domestic-water heaters and [**natural-gas**] [**LP-gas**] <**Insert fuel gas**> fuel.
g. Ignition: Standing pilot or ANSI Z21.20/CSA C22.2 No. 60730-2-5, electric, automatic, gas-ignition system.
h. Temperature Control: Adjustable thermostat.
i. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
j. 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 working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

6. Special Requirements: NSF 5 construction.
7. Draft Hood: Draft diverter, complying with ANSI Z21.12.
8. Automatic Damper: ANSI Z21.66/CSA 6.14, [**electrically operated**] [**mechanically activated**] [**thermally activated**], automatic-vent-damper device with size matching draft hood.

B. Commercial, Power-Burner, Gas-Fired, Storage, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: ANSI Z21.10.3/CSA 4.3.
4. Storage-Tank Construction: [**Non-**]ASME-code steel with [**150-psig**] <**Insert value**> working-pressure rating.
   a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
      1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
      2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
   b. Interior Finish: Comply with NSF 61 and NSF 372 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**] <**Insert material**> complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
5. Factory-Installed, Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.
   b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
   c. Drain Valve: Corrosion-resistant metal with hose-end connection.
   d. Insulation: Comply with ASHRAE/IES 90.1. Surround entire storage tank except connections and controls.
   e. Jacket: Steel with enameled finish.
   f. Burner: UL 795 for power-burner, gas-fired, domestic-water heaters and [**natural-gas**] [**LP-gas**] <**Insert fuel gas**> fuel.
   g. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 60730-2-5, electric, automatic, gas-ignition system.

h. Temperature Control: Adjustable thermostat.
i. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
j. 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 working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

6. Special Requirements: NSF 5 construction.
7. Draft Hood: [Draft diverter, complying with ANSI Z21.12] <Insert different hood or other arrangement>.

C. Commercial, Power-Vent, Gas-Fired, Storage, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: ANSI Z21.10.3/CSA 4.3.
4. Storage-Tank Construction: [**Non-**]ASME-code steel with [**150-psig**] <**Insert value**> working-pressure rating.
a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
b. Interior Finish: Comply with NSF 61 and NSF 372 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**] <**Insert material**> complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
5. Factory-Installed, Storage-Tank Appurtenances:
a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: Corrosion-resistant metal with hose-end connection.
d. Insulation: Comply with ASHRAE/IES 90.1. Surround entire storage tank except connections and controls.
e. Jacket: Steel with enameled finish.
f. Burner: For use with power-vent, gas-fired, domestic-water heaters and [**natural-gas**] [**LP-gas**] <**Insert fuel gas**> fuel.
g. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 60730-2-5, electric, automatic, gas-ignition system.
h. Temperature Control: Adjustable thermostat.
i. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
j. 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 working-pressure rating of

domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

6. Special Requirements: NSF 5 construction.
7. Power-Vent System: Exhaust fan, interlocked with burner.

D. Commercial, Direct-Vent, Gas-Fired, Storage, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: ANSI Z21.10.1/CSA 4.1.
4. Storage-Tank Construction: Steel.
   a. Tappings: ASME B1.20.1 pipe thread.
   b. Pressure Rating: 150 psig.
   c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
5. Factory-Installed Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.
   b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
   c. Drain Valve: Corrosion-resistant metal with hose-end connection.
   d. Insulation: Comply with ASHRAE/IES 90.1.
   e. Jacket: Steel with enameled finish.
   f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
   g. Burner: For use with direct-vent, gas-fired, domestic-water heaters and [**natural-gas**] [**LP-gas**] <**Insert fuel gas**> fuel.
   h. Ignition: Standing pilot or ANSI Z21.20/CSA C22.2 No. 60730-2-5, electric, automatic, gas-ignition system.
   i. Temperature Control: Adjustable thermostat.
   j. Combination Temperature-and-Pressure Relief Valve: ANSI Z21.22/CSA 4.4. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.
6. Direct-Vent System: Through-[**wall**] [**roof**], coaxial- or double-channel vent assembly with domestic-water heater manufacturers' outside intake/exhaust screen.

E. Commercial, Gas-Fired, High-Efficiency, Storage, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: ANSI Z21.10.3/CSA 4.3.
4. Description: Manufacturer's proprietary design to provide at least [**84**] [**85**] [**88**] [**95**] <**Insert number**> percent combustion efficiency at optimum operating conditions.
5. Storage-Tank Construction: ASME-code steel with [**150-psig**] <**Insert value**> minimum working-pressure rating.
   a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
      1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
      2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.

b. Interior Finish: Comply with NSF 61 and NSF 372 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**] <**Insert material**> complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.

6. Factory-Installed, Storage-Tank Appurtenances:
a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: Corrosion-resistant metal with hose-end connection.
d. Insulation: Comply with ASHRAE/IES 90.1. Surround entire storage tank except connections and controls.
e. Jacket: Steel with enameled finish.
f. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for gas-fired, high-efficiency, domestic-water heaters and [**natural-gas**] [**LP-gas**] <**Insert fuel gas**> fuel.
g. Temperature Control: Adjustable thermostat.
h. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
i. 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 working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

7. Draft Hood: [Draft diverter, complying with ANSI Z21.12] <Insert different hood or other arrangement>.

F. Capacity and Characteristics:
1. Capacity: <Insert **gal.** >.
2. Recovery: <Insert **gph**> at [**100 deg F**] <Insert temperature> temperature rise.
3. Temperature Setting: [**125 deg F**] [**140 deg F**] <Insert temperature>.
4. Fuel Gas Demand: <**Insert cfh**>.
5. Fuel Gas Input: <**Insert Btu/h**>.
6. Gas Pressure Regulator:
a. Capacity: <Insert **cfh**>.
b. Inlet Pressure: <**Insert psig or inches**> water column.
c. Gas Pressure Required at Burner: <**Insert psig or inches**> water column.
7. Electrical Characteristics:
a. Volts: [**120**] [**240**] [**277**] [**480**] <**Insert value**> V.
b. Phase: [**Single**] [**Three**].
c. Hertz: 60 Hz.
d. Full-Load Amperes: <**Insert value**> A.
e. Minimum Circuit Ampacity: <**Insert value**> A.
f. Maximum Overcurrent Protection: <**Insert value**> A.
8. Minimum Vent Diameter: <**Insert inches**>.

2.03 COMMERCIAL, FINNED-TUBE, GAS-FIRED, DOMESTIC-WATER HEATERS

A. Commercial, Coil-Type, Finned-Tube, Gas-Fired, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: ANSI Z21.13/CSA 4.9 for hot-water-supply boilers.
4. Description: Packaged unit with boiler, separate hot-water storage tank, pump, piping, and controls.
5. Boiler Construction: ASME code with [**160-psig**] <**Insert value**> working-pressure rating for hot-water-supply boiler, domestic-water heater.
   a. Heat Exchanger: Helix or spiral, finned-copper-tube coils with bronze headers.
   b. Connections: Factory fabricated of materials compatible with boiler. Attach to boiler before testing.
      1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
      2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
6. Boiler Appurtenances:
   a. Insulation: Comply with ASHRAE/IES 90.1. Surround entire boiler except connections and controls.
   b. Jacket: Steel with enameled finish.
   c. Burner: For use with coil-type, finned-tube, gas-fired, domestic-water heaters and [**natural-gas**] [**LP-gas**] <**Insert fuel gas**> fuel.
   d. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 60730-2-5, intermittent electronic-ignition system.
   e. Temperature Control: Adjustable, storage-tank temperature-control fitting and flow switch, interlocked with circulator and burner.
   f. Safety Control: Automatic, high-temperature-limit cutoff device or system.
7. Support: Steel base or skids.
8. Draft Hood: [Draft diverter, complying with ANSI Z21.12] <Insert different hood or other arrangement>.
9. Automatic Damper: ANSI Z21.66/CSA 6.14, [**electrically operated**] [**mechanically activated**] [**thermally activated**], automatic-vent-damper device with size matching draft hood.
10. Hot-Water Storage Tank: Connected with piping to circulating pump and domestic-water heater.
    a. Construction: In accordance with ASME Boiler and Pressure Vessel Code: Section VIII, steel with [**150-psig**] [**125-psig**] <**Insert value**> working-pressure rating.
    b. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
       1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
       2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
    c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
11. Factory-Installed, Storage-Tank Appurtenances:
    a. Anode Rods: Factory installed, magnesium.

b. Drain Valve: Corrosion-resistant metal with hose-end connection.
c. Insulation: Comply with ASHRAE/IES 90.1. Surround entire storage tank except connections and controls.
d. Jacket: Steel with enameled finish.
e. 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 working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

12. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, [**125-psig**] <**Insert value**> minimum working-pressure rating, and 225 deg F continuous-water-temperature rating.
13. Piping: Copper tubing; copper, solder-joint fittings; and brazed or flanged joints.
14. Mounting: Domestic-water heater, tank, and accessories factory mounted on skids.

B. Commercial, Grid-Type, Finned-Tube, Gas-Fired, Domestic-Water Heaters:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: ANSI Z21.13/CSA 4.9 for hot-water-supply boilers.
4. Description: Packaged unit with boiler, storage tank, pump, piping, and controls.
5. Boiler Construction: ASME code with [**160-psig**] <**Insert value**> working-pressure rating for hot-water-boiler-type, domestic-water heater.
   a. Heat Exchanger: Horizontal, straight, finned-copper tubes with bronze headers.
   b. Connections: Factory fabricated of materials compatible with boiler. Attach to boiler before testing.
      1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
      2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
6. Boiler Appurtenances:
   a. Insulation: Comply with ASHRAE/IES 90.1. Surround entire boiler except connections and controls.
   b. Jacket: Steel with enameled finish.
   c. Burner: For use with grid-type, finned-tube, gas-fired, domestic-water heaters and [**natural-gas**] [**LP-gas**] <**Insert fuel gas**> fuel.
   d. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 60730-2-5, intermittent electronic-ignition system.
   e. Temperature Control: Adjustable, storage-tank temperature-control fitting and flow switch, interlocked with circulator and burner.
   f. Safety Control: Automatic, high-temperature-limit cutoff device or system.
7. Support: Steel base or skids.
8. Draft Hood: [Draft diverter, complying with ANSI Z21.12] <Insert different hood or other arrangement>.
9. Automatic Damper: ANSI Z21.66/CSA 6.14, [**electrically operated**] [**mechanically activated**] [**thermally activated**], automatic-vent-damper device with size matching draft hood.

10. Hot-Water Storage Tank: Connected with piping to circulating pump and domestic-water heater.
    a. Construction: In accordance with ASME Boiler and Pressure Vessel Code: Section VIII, steel with [**150-psig**] [**125-psig**] <**Insert value**> working-pressure rating.
    b. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
        1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
        2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
    c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
11. Factory-Installed, Storage-Tank Appurtenances:
    a. Anode Rods: Factory installed, magnesium.
    b. Drain Valve: Corrosion-resistant metal with hose-end connection.
    c. Insulation: Comply with ASHRAE/IES 90.1. Surround entire storage tank except connections and controls.
    d. Jacket: Steel with enameled finish.
    e. 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 working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
12. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, [**125-psig**] <**Insert value**> minimum working-pressure rating, and 225 deg F continuous-water-temperature rating.
13. Piping: Copper tubing; copper, solder-joint fittings; and brazed or flanged joints.
14. Mounting: Domestic-water heater, tank, and accessories factory mounted on skids.

C. Capacity and Characteristics:
1. Hot-Water Storage-Tank Capacity: <**Insert gal.** >.
2. Recovery: <Insert **gph**> at [**100 deg F**] <Insert temperature> temperature rise.
3. Temperature Setting: [**125 deg F**] [**140 deg F**] <Insert temperature>.
4. Fuel Gas Demand: <**Insert cfh**>.
5. Fuel Gas Input: <**Insert Btu/h**>.
6. Gas Pressure Regulator:
    a. Capacity: <Insert **cfh**>.
    b. Inlet Pressure: <**Insert psig or inches**> water column.
    c. Gas Pressure Required at Burner: <**Insert psig or inches**> water column.
7. Electrical Characteristics:
    a. Volts: [**120**] [**240**] [**277**] [**480**] <**Insert value**> V.
    b. Phase: [**Single**] [**Three**].
    c. Hertz: 60 Hz.
    d. Full-Load Amperes: <**Insert value**> A.
    e. Minimum Circuit Ampacity: <**Insert value**> A.
    f. Maximum Overcurrent Protection: <**Insert value**> A.

8. Minimum Vent Diameter: <**Insert inches**>.

2.04 GAS-FIRED, TANKLESS, DOMESTIC-WATER HEATERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.

C. Standard: ANSI Z21.10.3/CSA 4.3 for gas-fired, instantaneous, domestic-water heaters for indoor application.

D. Construction: Copper piping or tubing complying with NSF 61 and NSF 372 barrier materials for potable water, without storage capacity.

1. Tappings: ASME B1.20.1 pipe thread.
2. Pressure Rating: 150 psig.
3. Heat Exchanger: [Copper tubing] [Stainless steel].
4. Insulation: Comply with [**ASHRAE/IES 90.1**] [**ASHRAE 90.2**].
5. Jacket: Metal, with enameled finish, or plastic.
6. Burner: For use with tankless, domestic-water heaters and [**natural-gas**] [**LP-gas**] <**Insert fuel gas**> fuel.
7. Automatic Ignition: Manufacturer's proprietary system for automatic, gas ignition.
8. Temperature Control: Adjustable thermostat.

E. Support: Bracket for wall mounting.

F. Capacity and Characteristics:

1. Flow Rate: <Insert **gpm**> at [**100 deg F**] <Insert temperature> temperature rise.
2. Temperature Setting: [**125 deg F**] [**140 deg F**] <Insert temperature>.
3. Fuel Gas Demand: <**Insert cfh**>.
4. Fuel Gas Input: <**Insert Btu/h**>.
5. Gas Pressure Regulator:
   a. Capacity: <Insert **cfh**>.
   b. Inlet Pressure: <**Insert psig or inches**> water column.
   c. Gas Pressure Required at Burner: <**Insert psig or inches**> water column.
6. Electrical Characteristics:
   a. Volts: [**120**] <**Insert value**> V.
   b. Phase: Single.
   c. Hertz: 60 Hz.
   d. Full-Load Amperes: <**Insert value**> A.
   e. Minimum Circuit Ampacity: <**Insert value**> A.
   f. Maximum Overcurrent Protection: <**Insert value**> A.
7. Minimum Vent Diameter: <**Insert inches**>.

2.05 RESIDENTIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

A. Residential, Atmospheric, Gas-Fired, Storage, Domestic-Water Heaters:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: ANSI Z21.10.1/CSA 4.1.
4. Storage-Tank Construction: Steel.
   a. Tappings: ASME B1.20.1 pipe thread.
   b. Pressure Rating: 150 psig.
   c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
5. Factory-Installed, Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.

b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: Corrosion-resistant metal with hose-end connection.
d. Insulation: Comply with [**ASHRAE/IES 90.1**] [**ASHRAE 90.2**].
e. Jacket: Steel with enameled finish.
f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
g. Burner: For use with atmospheric, gas-fired, domestic-water heaters and [**natural-gas**] [**LP-gas**] <**Insert fuel gas**> fuel.
h. Ignition: Standing pilot or ANSI Z21.20/CSA C22.2 No. 60730-2-5, electric, automatic, gas-ignition system.
i. Temperature Control: Adjustable thermostat.
j. Combination Temperature-and-Pressure Relief Valve: ANSI Z21.22/CSA 4.4. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.

6. Draft Hood: Low-profile-type draft diverter, complying with ANSI Z21.12.
7. Automatic Damper: ANSI Z21.66/CSA 6.14, [**electrically operated**] [**mechanically activated**] [**thermally activated**], automatic-vent-damper device with size matching draft hood.

B. Residential, Direct-Vent, Gas-Fired, Storage, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: ANSI Z21.10.1/CSA 4.1.
4. Storage-Tank Construction: Steel.
a. Tappings: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig.
c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
5. Factory-Installed, Storage-Tank Appurtenances:
a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: Corrosion-resistant metal with hose-end connection.
d. Insulation: Comply with [**ASHRAE/IES 90.1**] [**ASHRAE 90.2**].
e. Jacket: Steel with enameled finish.
f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
g. Burner: For use with direct-vent, gas-fired, domestic-water heaters and [**natural-gas**] [**LP-gas**] <**Insert fuel gas**> fuel.
h. Ignition: Standing pilot or ANSI Z21.20/CSA C22.2 No. 60730-2-5, electric, automatic, gas-ignition system.
i. Temperature Control: Adjustable thermostat.
j. Combination Temperature-and-Pressure Relief Valve: ANSI Z21.22/CSA 4.4. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.
6. Direct-Vent System: Through-[**wall**] [**roof**], coaxial- or double-channel vent assembly with domestic-water heater manufacturers' outside intake/exhaust screen.

C. Residential, Power-Vent, Gas-Fired, Storage, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: ANSI Z21.10.1/CSA 4.1.
4. Storage-Tank Construction: Steel.
   a. Tappings: ASME B1.20.1 pipe thread.
   b. Pressure Rating: 150 psig.
   c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
5. Factory-Installed, Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.
   b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
   c. Drain Valve: Corrosion-resistant metal with hose-end connection.
   d. Insulation: Comply with [**ASHRAE/IES 90.1**] [**ASHRAE 90.2**].
   e. Jacket: Steel with enameled finish.
   f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
   g. Burner: For use with power-vent, gas-fired, domestic-water heaters and [**natural-gas**] [**LP-gas**] <**Insert fuel gas**> fuel.
   h. Ignition: Standing pilot or ANSI Z21.20/CSA C22.2 No. 60730-2-5, electric, automatic, gas-ignition system.
   i. Temperature Control: Adjustable thermostat.
   j. Combination Temperature-and-Pressure Relief Valve: ANSI Z21.22/CSA 4.4. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.
6. Power-Vent System: Exhaust fan, interlocked with burner.

D. Capacity and Characteristics:
1. Capacity: <Insert **gal.** >.
2. Recovery: <Insert **gph**> at [**100 deg F**] <Insert temperature> temperature rise.
3. Temperature Setting: [**125 deg F**] <Insert temperature>.
4. Fuel Gas Demand: <**Insert cfh**>.
5. Fuel Gas Input: <**Insert Btu/h**>.
6. Gas Pressure Regulator:
   a. Capacity: <Insert **cfh**>.
   b. Inlet Pressure: <**Insert psig or inches**> water column.
   c. Gas Pressure Required at Burner: <**Insert psig or inches**> water column.
7. Electrical Characteristics:
   a. Volts: [**120**] [**240**] <**Insert value**> V.
   b. Phase: [**Single**] [**Three**].
   c. Hertz: 60 Hz.
   d. Full-Load Amperes: <**Insert value**> A.
   e. Minimum Circuit Ampacity: <**Insert value**> A.
   f. Maximum Overcurrent Protection: <**Insert value**> A.
8. Minimum Vent Diameter: <**Insert inches**>.

2.06 OIL-FIRED, DOMESTIC-WATER HEATERS

A. Commercial, Oil-Fired, Storage, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: UL 732 for storage, domestic-water heaters.

4. Storage-Tank Construction: [**Non-**]ASME-code steel with [**150-psig**] <**Insert value**> minimum working-pressure rating.
   a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
      1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
      2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
   b. Interior Finish: Comply with NSF 61 and NSF 372 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**] <**Insert material**> complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
5. Factory-Installed, Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.
   b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
   c. Drain Valve: Corrosion-resistant metal with hose-end connection.
   d. Insulation: Comply with ASHRAE/IES 90.1.
   e. Jacket: Steel with enameled finish.
   f. Temperature Control: Adjustable thermostat.
   g. Relief Valves: ASME rated and stamped 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 working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
6. Oil Burners:
   a. Standard: UL 296 for use with No. 2 fuel oil.
   b. Safety Control: Automatic, high-temperature-limit cutoff device or system.
   c. Draft Regulator: Barometric type or adjustable-damper device.

B. Commercial, Large-Volume, Oil-Fired, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: UL 732 for storage, domestic-water heaters except when capacity is greater than 120 gal..
4. Storage-Tank Construction: ASME-code steel with [**150-psig**] <**Insert value**> minimum working-pressure rating.
   a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
      1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
      2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.

b. Interior Finish: Comply with NSF 61 and NSF 372 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**] <**Insert material**> complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.

5. Factory-Installed, Storage-Tank Appurtenances:
a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: Corrosion-resistant metal with hose-end connection.
d. Insulation: Comply with ASHRAE/IES 90.1.
e. Jacket: Steel with enameled finish.
f. Temperature Control: Adjustable thermostat.
g. Safety Control: Automatic, high-temperature-limit cutoff device or system.
h. Relief Valves: ASME rated and stamped 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 working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

6. Oil Burners:
a. Standard: UL 296 for use with No. 2 fuel oil.
b. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
c. Draft Regulator: Barometric type or adjustable-damper device.

C. Residential, Oil-Fired, Storage, Domestic-Water Heaters:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. Standard: UL 732 for storage, domestic-water heaters.
4. Storage-Tank Construction: Steel.
a. Tappings: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig.
c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.

5. Factory-Installed, Storage-Tank Appurtenances:
a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: Corrosion-resistant metal with hose-end connection.
d. Insulation: Comply with [**ASHRAE/IES 90.1**] [**ASHRAE 90.2**].
e. Jacket: Steel with enameled finish.
f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
g. Temperature Control: Adjustable thermostat.
h. Relief Valves: ASME rated and stamped 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 working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

6. Oil Burner: UL 296 for use with No. 2 fuel oil.

7. Draft Regulator: Barometric type or adjustable-damper device.

D. Capacity and Characteristics:
1. Capacity: <Insert **gal.** >.
2. Recovery: <Insert **gph**> at [**100 deg F**] <Insert temperature> temperature rise.
3. Temperature Setting: [**125 deg F**] [**140 deg F**] <Insert temperature>.
4. Fuel-Oil Demand: <**Insert gpm**>.
5. Fuel-Oil Input: <**Insert Btu/h**>.
6. Electrical Characteristics:
a. Burner Horsepower: <**Insert value**>.
b. Volts: [**120**] [**240**] [**277**] [**480**] <**Insert value**> V.
c. Phase: [**Single**] [**Three**].
d. Hertz: 60 Hz.
e. Full-Load Amperes: <**Insert value**> A.
f. Minimum Circuit Ampacity: <**Insert value**> A.
g. Maximum Overcurrent Protection: <**Insert value**> A.
7. Minimum Vent Diameter: <**Insert inches**>.

2.07 COMMERCIAL, GAS- AND OIL-FIRED, DOMESTIC-WATER HEATERS

A. Description: Comply with ANSI Z21.10.3/CSA 4.3 or UL 732 requirements appropriate for dual-fuel, gas- and oil-fired, domestic-water heaters.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.

D. Storage-Tank Construction: ASME-code steel with [**150-psig**] <**Insert value**> minimum working-pressure rating.
1. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
a. NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
b. NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
2. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
3. Lining: [**Cement**] [**Glass**] [**Nickel plate**] [**Phenolic coating**] [**Sheet copper**] <**Insert material**> complying with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.

E. Factory-Installed, Storage-Tank Appurtenances:
1. Anode Rod: Replaceable magnesium.
2. Dip Tube: Required unless cold-water inlet is near bottom of tank.
3. Drain Valve: Corrosion-resistant metal with hose-end connection.
4. Insulation: Comply with ASHRAE/IES 90.1.
5. Jacket: Steel with enameled finish.
6. Temperature Control: Adjustable thermostat.
7. Relief Valves: ASME rated and stamped 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 working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

F. Fuel Burner:

1. Standards: Combination gas-and-oil burner assembly, complying with appropriate requirements of UL 795; or comply with UL 296 for oil burners for No. 2 fuel oil and UL 795 for [**natural-gas**] [**LP-gas**] <**Insert fuel gas**> fuel.
2. Safety Control: Automatic, high-temperature-limit cutoff device or system.
3. Vent Connection: In accordance with standards of authorities having jurisdiction for dual-fuel, domestic-water heaters.

G. Capacity and Characteristics:
1. Capacity: <Insert **gal.** >.
2. Recovery: <Insert **gph**> at [**100 deg F**] <Insert temperature> temperature rise.
3. Temperature Setting: [**125 deg F**] [**140 deg F**] <Insert temperature>.
4. Fuel Gas Demand: <**Insert cfh**>.
5. Fuel Gas Input: <**Insert Btu/h**>.
6. Gas Pressure Regulator:
   a. Capacity: <Insert **cfh**>.
   b. Inlet Pressure: <**Insert psig or inches**> water column.
   c. Gas Pressure Required at Burner: <**Insert psig or inches**> water column.
7. Fuel-Oil Demand: <**Insert gpm**>.
8. Fuel-Oil Input: <**Insert Btu/h**>.
9. Electrical Characteristics:
   a. Burner Horsepower: <**Insert value**>.
   b. Volts: [**120**] [**240**] <**Insert value**> V.
   c. Phase: [**Single**] [**Three**].
   d. Hertz: 60 Hz.
   e. Full-Load Amperes: <**Insert value**> A.
   f. Minimum Circuit Ampacity: <**Insert value**> A.
   g. Maximum Overcurrent Protection: <**Insert value**> A.
10. Minimum Vent Diameter: <**Insert inches**>.

2.08 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Expansion Tanks:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
3. 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.
4. Construction:
   a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
   b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   c. Air-Charging Valve: Factory installed.
5. Capacity and Characteristics:
   a. Working-Pressure Rating: [**100 psig**] [**150 psig**] <Insert value>.
   b. Capacity Acceptable: [**2 gal.**] [**4 gal.**] [**7 gal.**] [**10 gal.**] <Insert value> minimum.
   c. Air Precharge Pressure: <**Insert system pressure**>.

B. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 with ASME B1.20.1 pipe threads.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement in accordance with ASHRAE/IES 90.1.
D. Heat-Trap Fittings: ASHRAE 90.2.
E. Manifold Kits: Domestic-water heater manufacturer's factory-fabricated inlet and outlet piping for field installation, for multiple domestic-water heater installation. Include ball-, butterfly-, or gate-type shutoff valves to isolate each domestic-water heater and [**calibrated**] [**memory-stop**] balancing valves to provide balanced flow through each domestic-water heater.
F. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
    1. Comply with requirements for balancing valves specified in Section 221119 "Domestic Water Piping Specialties."
G. Gas Shutoff Valves: ANSI Z21.15/CSA 9.1, manually operated. Furnish for installation in piping.
H. Gas Pressure Regulators: ANSI Z21.18/CSA 6.3, appliance type. Include [**1/2-psig**] [**2-psig**] [**5-psig**] pressure rating as required to match gas supply.
I. Automatic Gas Valves: ANSI Z21.21/CSA 6.5, appliance, electrically operated, on-off automatic valve.
J. Combination Temperature-and-Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valves with sensing element that extends into storage tank.
    1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4.
    2. Oil-Fired, Domestic-Water Heaters: ASME rated and stamped.
K. Pressure Relief Valves: Include pressure setting less than working-pressure rating of domestic-water heater.
    1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4.
    2. Oil-Fired, Domestic-Water Heaters: ASME rated and stamped.
L. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.
M. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Provide dimension that will support bottom of domestic-water heater minimum of [**18 inches**] <**Insert dimension**> above the floor.
N. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.09 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled domestic-water heaters[**and storage tanks**] specified to be ASME-code construction, in accordance with ASME Boiler and Pressure Vessel Code.
B. Hydrostatically test[**commercial**] domestic-water heaters[**and storage tanks**] to minimum of one and one-half times pressure rating before shipment.
C. Domestic-water heaters will be considered defective if they do not pass tests and inspections.
D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 INSTALLATION OF DOMESTIC-WATER HEATER

A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Exception: Omit concrete bases for commercial domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
2. Maintain manufacturer's recommended clearances.
3. Arrange units so controls and devices that require servicing are accessible.
4. 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 concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Install anchor bolts to elevations required for proper attachment to supported equipment.
8. Anchor domestic-water heaters to substrate.

B. Residential, Domestic-Water Heater Mounting: Install residential domestic-water heaters on [**floor**] [**water-heater stand on floor**] [**domestic-water heater mounting bracket**].
   1. Maintain manufacturer's recommended clearances.
   2. Arrange units so controls and devices that require servicing are accessible.
   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. Anchor domestic-water heaters to substrate.

C. Tankless, Domestic-Water Heater Mounting: Install tankless, domestic-water heaters[**at least 18 inches above floor**] on wall bracket.
   1. Maintain manufacturer's recommended clearances.
   2. Arrange units so controls and devices that require servicing are accessible.
   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. Anchor domestic-water heaters to substrate.

D. Install domestic-water heaters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
   1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."

E. Install gas-fired, domestic-water heaters in accordance with NFPA 54.
   1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
   2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
   3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
   4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves specified in [**Section 231123 "Facility Natural-Gas Piping."**] [**Section 231126 "Facility Liquefied-Petroleum Gas Piping."**]

F. Install oil-fired, domestic-water heaters in accordance with NFPA 31.
   1. Install shutoff valves on fuel-oil supply piping to oil-fired water-heater burners without shutoff valves. Comply with requirements for shutoff valves specified in Section 231113 "Facility Fuel-Oil Piping."

G. Install commercial domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" and Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

H. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-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 [**combination temperature-and-**]pressure relief valves in water piping for domestic-water heaters without storage. Extend domestic-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.

J. 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 domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."

K. Install thermometer on outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."

L. Assemble and install inlet and outlet piping manifold kits for multiple domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each domestic-water heater outlet. Comply with requirements for valves specified in Section 220523 "General-Duty Valves for Plumbing Piping" and comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."

M. Install piping-type heat traps on inlet and outlet piping of domestic-water heater storage tanks without integral or fitting-type heat traps.

N. Fill domestic-water heaters with water.

O. Charge domestic-water expansion tanks with air to required system pressure.

P. Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water shall contain less than 0.25 percent of lead by weight.

3.02 PIPING CONNECTIONS

A. Comply with requirements for domestic-water piping specified in Section 221116 "Domestic Water Piping."

B. Comply with requirements for fuel-oil piping specified in Section 231113 "Facility Fuel-Oil Piping."

C. Comply with requirements for gas piping specified in [Section 231123 "Facility Natural-Gas Piping."] [Section 231126 "Facility Liquefied-Petroleum Gas Piping."]

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

E. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.03 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.04 FIELD QUALITY CONTROL

A. Testing Agency:
   1. Owner will engage a qualified testing agency to perform tests and inspections.
   2. Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections[with the assistance of a factory-authorized service representative].

D. 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 operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Domestic-water heaters will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.05 DEMONSTRATION

A. [Engage a factory-authorized service representative to train] [Train] Owner's maintenance personnel to adjust, operate, and maintain [commercial, gas-fired, storage,] [gas-fired, tankless] [commercial, oil-fired,] [commercial, gas- and oil-fired,] domestic-water heaters. Training shall be a minimum of [one] [two] <Insert duration> hour(s).

END OF SECTION

SECTION 224200
COMMERCIAL PLUMBING FIXTURES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Commercial lavatories.
   2. Commercial showers.
   3. Commercial sinks.
   4. Commercial urinals.
   5. Commercial water closets.
   6. Commercial wash fountains.
   7. Flushometer valves.
   8. Toilet seats.
   9. Fixture carriers.

B. Related Requirements:
   1. Section 114000 "Foodservice Equipment" for NSF-compliant foodservice and handwash sinks.
   2. Section 224100 "Residential Plumbing Fixtures" for residential plumbing fixtures.
   3. Section 224300 "Healthcare Plumbing Fixtures" for healthcare plumbing fixtures.
   4. Section 224500 "Emergency Plumbing Fixtures" for emergency plumbing fixtures.
   5. Section 224600 "Security Plumbing Fixtures" for security plumbing fixtures.

1.02 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.
B. PMMA: Polymethyl methacrylate; also known as "acrylic."
C. Standard-Efficiency Flush Volume: 1.6 gal. per flush.
D. High-Efficiency Flush Volume: 1.28 gal. or less per flush.
E. WaterSense Fixture: Water closet and/or flushometer valve/tank certified by the EPA to meet the WaterSense performance criteria.

1.03 ACTION SUBMITTALS

A. Product Data:
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for plumbing fixtures.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:
   1. Plans, elevations, sections, and [**mounting**] [**attachment**] details.
   2. Details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:
   1. <Double click to insert sustainable design text for plumbing fixtures.>

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories and/or counter-mounted sinks.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:
   1. For lavatories and faucets.

a. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
1) Servicing and adjustments of automatic faucets.
2. For shower valves to include in maintenance manuals
3. For sinks and faucets to include in operation and maintenance manuals.
a. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
1) Servicing and adjustments of automatic faucets.
4. For flushometer valves[**and electronic sensors**] to include in operation and maintenance manuals.
5. For wash fountains and components to include in operation and maintenance manuals.

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Faucet Washers and O-Rings: Equal to [**10**] <**Insert number**> percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to [**5**] <**Insert number**> percent of amount of each type and size installed.
3. Shower Valve Washers and O-Rings: Equal to [**10**] <**Insert number**> percent of amount of each type and size installed.
4. Shower Valve Cartridges and O-Rings: Equal to [**5**] <**Insert number**> percent of amount of each type and size installed.
5. Waterless Urinal Trap-Seal Cartridges: Equal to [**200**] <**Insert number**> percent of amount of each type installed, but no fewer than [**12**] <**Insert number**> of each type.
6. Waterless Urinal Trap-Seal Liquid: Equal to [**1 gal.**] <**Insert volume**> for each urinal installed.
7. Flushometer-Valve Repair Kits: Equal to [**10**] <**Insert number**> percent of amount of each type installed, but no fewer than [**one**] [**six**] <**Insert number**> of each type.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Lavatory faucets, sink faucets, shower valves, and wash fountain spray heads and faucets intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), with requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61 and NSF 372, or be certified in compliance with NSF 61 and NSF 372 by an ANSI-accredited third-party certification body, in that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.
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.

2.02 COMMERCIAL LAVATORIES

A. Lavatories, Counter Mounted:
1. Lavatories, Counter Mounted - Enameled Cast Iron, Flat Rim, Flush Mount <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Fixture:
1) Standard: ASME A112.19.1/CSA B45.2.
2) Type: For flush mounting with kit.
3) Nominal Size: Rectangular, [**18 by 15 inches**] [**20 by 18 inches**].

4) Faucet-Hole Punching: [Three holes, **2-inch**] [Three holes, **4-inch**] centers.
5) Faucet-Hole Location: Top.
6) Color: [White] <Insert color>.
7) Mounting Materials: With stainless steel ring and sealant.

c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.

2. Lavatories, Counter Mounted - Enameled Cast Iron, Self-Rimming <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Fixture:
1) Standard: ASME A112.19.1/CSA B45.2.
2) Type: Self-rimming for above-counter mounting.
3) Nominal Size: Oval, [**20 by 17 inches**] <Insert dimensions> nominal.
4) Faucet-Hole Punching: [Single center hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers].
5) Faucet-Hole Location: Top.
6) Color: [White] <Insert color>.
7) Mounting Material: Sealant.

c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.

3. Lavatories, Undercounter Mounted - Enameled Cast Iron <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Fixture:
1) Standard: ASME A112.19.1/CSA B45.2.
2) Type: For undercounter mounting.
3) Nominal Size: Oval, [**20 by 17 inches**] <Insert dimensions> nominal.
4) Faucet-Hole Punching: No holes.
5) Faucet-Hole Location: On countertop.
6) Color: [White] <Insert color>.
7) Mounting Materials: Sealant and undercounter mounting kit.

c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.

4. Lavatory, Counter Mounted - Vitreous China, Self-Rimming, Rectangular <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Fixture:
1) Standard: ASME A112.19.2/CSA B45.1.
2) Type: Self-rimming for above-counter mounting.
3) Nominal Size: Rectangular, [**21 by 19 inches**] [**24 by 20 inches**] <Insert dimensions> nominal.
4) Faucet-Hole Punching: [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers].
5) Faucet-Hole Location: Top.
6) Color: [White] <Insert color>.
7) Mounting Material: Sealant.

c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.

5. Lavatory, Counter Mounted - Vitreous China, Self-Rimming, Oval or Round <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Fixture:

1) Standard: ASME A112.19.2/CSA B45.1.

2) Type: Self-rimming for above-counter mounting.

3) Nominal Size:

a) Oval, [**19 by 17 inches**] [**20 by 17 inches**] <Insert dimensions>.

b) Round, [**19 inches**] <Insert dimension>.

4) Faucet-Hole Punching: [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers].

5) Faucet-Hole Location: Top.

6) Color: [White] <Insert color>.

7) Mounting Material: Sealant.

c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.

6. Lavatories, Undercounter Mounted - Vitreous China, Oval <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Fixture:

1) Standard: ASME A112.19.2/CSA B45.1.

2) Type: For undercounter mounting.

3) Nominal Size: Oval, [**19 by 16 inches**] [**22 by 14 inches**] [**23 by 15 inches**] <Insert dimensions>.

4) Faucet-Hole Punching: No holes.

5) Faucet-Hole Location: On countertop.

6) Color: [White] <Insert color>.

7) Mounting Material: Sealant and undercounter mounting kit.

c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.

B. Lavatories, Wall Mounted:

1. Lavatory, Wall Mounted - Enameled Cast Iron, Rectangular <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Fixture:

1) Standard: ASME A112.19.1/CSA B45.2.

2) Type: Straight-front apron with straight back.

3) Nominal Size: Rectangular, [**19 by 17 inches**] [**20 by 18 inches**].

4) Faucet-Hole Punching: [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers].

5) Faucet-Hole Location: Top.

6) Color: [White] <Insert color>.

7) Mounting Material: Wall bracket.

c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
d. Support: [Lavatory carrier, framing affixed] [Lavatory carrier, floor affixed with steel uprights] <Insert carrier>.
e. Lavatory Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

2. Lavatories, Wall Mounted - Vitreous China, Rectangular with Back <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Fixture:
1) Standard: ASME A112.19.2/CSA B45.1.
2) Type: For wall hanging.
3) Nominal Size: Rectangular, [**18 by 16 inches**] [**20 by 18 inches**] <Insert dimensions>.
4) Faucet-Hole Punching: [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers].
5) Faucet-Hole Location: Top.
6) Color: [White] <Insert color>.
7) Mounting Material: Chair carrier.
c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
d. Support: [Lavatory carrier, framing affixed] [Lavatory carrier, floor affixed with steel uprights] [,] [exposed arm] [concealed arm] <Insert carrier>.
e. Lavatory Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

3. Lavatories, Wall Mounted - Vitreous China, Rectangular with Ledge Back <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Fixture:
1) Standard: ASME A112.19.2/CSA B45.1.
2) Type: For wall hanging.
3) Nominal Size: Rectangular, [**19 by 17 inches**] [**20 by 18 inches**] <Insert dimensions>.
4) Faucet-Hole Punching: [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers].
5) Faucet-Hole Location: Top.
6) Color: [White] <Insert color>.
7) Mounting Material: Chair carrier.
c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
d. Support: [Lavatory carrier, framing affixed] [Lavatory carrier, floor affixed with steel uprights] [,] [exposed arm] [concealed arm] <Insert carrier>.
e. Lavatory Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

4. Lavatories, Wall Mounted - Vitreous China, Rectangular, Wheelchair <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Fixture:
   1) Standard: ASME A112.19.2/CSA B45.1.
   2) Type: Wheelchair.
   3) Nominal Size: Rectangular, 27 by 20 inches.
   4) Faucet-Hole Punching: [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers] [Three holes, **5- to 6-inch** centers].
   5) Faucet-Hole Location: Top.
   6) Color: [White] <Insert color>.
   7) Mounting: For concealed-arm carrier.

c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.

d. Support: [Lavatory carrier, floor affixed with steel uprights] [,] [exposed-arm] [concealed-arm] <Insert carrier>.

e. Lavatory Mounting Height: [Juvenile] [Accessible in accordance with ICC A117.1].

5. Lavatories, Wall Mounted - Vitreous China, Corner Type <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Fixture:
   1) Standard: ASME A112.19.2/CSA B45.1.
   2) Type: Three-sided-front apron with three-sided back.
   3) Nominal Size: Corner, 16 by 16 inches.
   4) Faucet-Hole Punching: [One hole] [Three holes, **2-inch** centers].
   5) Faucet-Hole Location: Back wall.
   6) Color: [White] <Insert color>.
   7) Mounting Materials: Wall brackets.

c. Faucet: Manufacturer's standard; factory installed.

d. Support: [Lavatory carrier, framing affixed] [Lavatory carrier, floor affixed with steel uprights] <Insert carrier>.

e. Lavatory Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

6. Lavatories, Wall Mounted - Precast GFRC, Rectangular Countertop Deck with Integral Ramp Basin(s) <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Basin(s) and Countertop:
   1) Standard: CSA B45.8/IAPMO Z403 and ICC A117.1.
   2) Type: Straight front and side aprons with straight back.
   3) Number of Stations: [**One**] [**Two**] [**Three**] [**Four**].
   4) Overall Countertop Size: [**30 by 21 by 5 inches (per station**] <Insert dimension>.
   5) Basin I.D.: [**20 by 13 by 5 inches**] [**18 by 12 by 5 inches**] [**14 by 10 by 5 inches**].
   6) Faucet-Hole Punching (per Station): [Zero holes] [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers] <Insert hole pattern>.
   7) Faucet-Hole Location: [**Top**] [**Wall mount**].
   8) Drain Type: Slot drain

9) Color: [White linen] [Concrete] [Charcoal] [Limestone] [Graphite] [Pewter] [Dusk] [Taupe] <Insert color>.
10) Mounting: Concrete wall brackets.

c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.

d. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Connection: 1-1/4-inch fine thread tailpiece.
3) Finish: [Polished chrome] [Brushed nickel] [Oil-rubbed bronze].

e. Support: Manufacturer's standard product.

f. Lavatory Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

7. Lavatories, Wall Mounted - Precast GFRC, Rectangular Countertop Deck with Integral Rectangular Basin(s) <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Basin(s) and Countertop:
1) Standard: CSA B45.8/IAPMO Z403 and ICC A117.1.
2) Type: Straight front and side aprons with straight back.
3) Number of Stations: [**One**] [**Two**] [**Three**] [**Four**].
4) Overall Countertop Size: [**30 by 21 by 5 inches (per station**] <Insert dimension>.
5) Basin I.D.: 20 by 13 by 5 inches.
6) Faucet-Hole Punching (per Station): [Zero holes] [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers] <Insert hole pattern>.
7) Faucet-Hole Location: [**Top**] [**Wall mount**].
8) Drain Type: 1-1/4-inch grid drain assembly.
9) Color: [White linen] [Concrete] [Charcoal] [Limestone] [Graphite] [Pewter] [Dusk] [Taupe] <Insert color>.
10) Mounting: Concrete wall brackets.

c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.

d. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Type: 1-1/4-inch grid drain assembly.
3) Finish: [Polished chrome] [Brushed nickel] [Oil-rubbed bronze].

e. Support: Manufacturer's standard product.

f. Lavatory Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

8. Lavatories, Wall Mounted - Precast GFRC, Rectangular Countertop Deck with Integral Half-Trough Basin(s) <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Fixture:
1) Standard: CSA B45.8/IAPMO Z403 and ICC A117.1.
2) Type: Straight front and side aprons with straight back.
3) Number of Stations: [**One**] [**Two**] [**Three**] [**Four**].
4) Overall Countertop Size: [**30 by 21 by 5 inches (per station**] <Insert dimension>.

5) Basin I.D.: [**20 by 13 by 5-1/2 inches**] [**16 by 14 by 5-1/2 inches**].
6) Faucet-Hole Punching (per Station): [Zero holes] [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers] <Insert hole pattern>.
7) Faucet-Hole Location: [**Top**] [**Wall mount**].
8) Drain Type: 1-1/4-inch grid drain assembly.
9) Color: [White linen] [Concrete] [Charcoal] [Limestone] [Graphite] [Pewter] [Dusk] [Taupe] <Insert color>.
10) Mounting: Concrete wall brackets.

c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
d. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Type: 1-1/4-inch grid drain assembly.
3) Finish: [Polished chrome] [Brushed nickel] [Oil-rubbed bronze].
e. Support: Manufacturer's standard product.
f. Lavatory Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

9. Lavatories, Wall Mounted - Precast GFRC, Rectangular Countertop Deck with Single Integral Ramp Basin, Two Station <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Fixture:
1) Standard: CSA B45.8/IAPMO Z403 and ICC A117.1.
2) Type: Straight front and side aprons with straight back.
3) Overall Countertop Size: [**60 by 21 by 5 inches**] [**72 by 21 by 5 inches**] <Insert dimension>.
4) Basin I.D.: [**48 by 13 by 5 inches**] [**50 by 12 by 5 inches**] [**50 by 13 by 5 inches**] [**60 by 13 by 5 inches**].
5) Faucet-Hole Punching (per Station): [Zero holes] [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers] <Insert hole pattern>.
6) Faucet-Hole Location: [**Top**] [**Wall mount**].
7) Drain Type: Slot drain.
8) Color: [White linen] [Concrete] [Charcoal] [Limestone] [Graphite] [Pewter] [Dusk] [Taupe] <Insert color>.
9) Mounting Material: Concrete wall brackets.
c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
d. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Type: 1-1/2-inch slip joint connection.
3) Finish: [Polished chrome] [Brushed nickel] [Oil-rubbed bronze].
e. Support: Manufacturer's standard product.
f. Lavatory Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

10. Lavatories, Wall Mounted - Precast GFRC, Rectangular Countertop Deck with a Single Integral Ramp Basin, Three Station <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Fixture:

1) Standard: CSA B45.8/IAPMO Z403 and ICC A117.1.
2) Type: Straight front and side aprons with straight back.
3) Overall Countertop Size: [**72 by 21 by 5 inches**] [**90 by 21 by 5 inches**] <Insert dimension>.
4) Basin I.D.: [**60 by 13 by 5 inches**] [**72 by 13 by 5 inches**] [**80 by 12 by 5 inches**] [**84 by 12 by 5 inches**].
5) Faucet-Hole Punching (per Station): [Zero holes] [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers] <Insert hole pattern>.
6) Faucet-Hole Location: [**Top**] [**Wall mount**].
7) Drain Type: Slot drain.
8) Color: [White linen] [Concrete] [Charcoal] [Limestone] [Graphite] [Pewter] [Dusk] [Taupe] <Insert color>.
9) Mounting Material: Concrete wall brackets.

c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
d. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Type: 1-1/2-inch slip joint connection.
3) Finish: [Polished chrome] [Brushed nickel] [Oil-rubbed bronze].
e. Support: Manufacturer's standard product.
f. Lavatory Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

11. Lavatories, Wall Mounted - Precast GFRC, Rectangular Countertop Deck with Single Integral Ramp Basin, Four Station <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Fixture:
1) Standard: CSA B45.8/IAPMO Z403 and ICC A117.1.
2) Type: Straight front and side aprons with straight back.
3) Overall Countertop Size: [**106 by 21 by 5 inches**] [**120 by 21 by 5 inches**] <Insert dimension>.
4) Basin I.D.: [**96 by 12 by 5 inches**] [**110 by 12 by 5 inches**].
5) Faucet-Hole Punching (per Station): [Zero holes] [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers] <Insert hole pattern>.
6) Faucet-Hole Location: [**Top**] [**Wall mount**].
7) Drain Type: Slot drain.
8) Color: [White linen] [Concrete] [Charcoal] [Limestone] [Graphite] [Pewter] [Dusk] [Taupe] <Insert color>.
9) Mounting Material: Concrete wall brackets.

c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
d. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Type: 1-1/2-inch slip joint connection.
3) Finish: [Polished chrome] [Brushed nickel] [Oil-rubbed bronze].
e. Support: Manufacturer's standard product.
f. Lavatory Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

C. Lavatories, Freestanding:

1. Lavatories, Freestanding - Precast GFRC, Rectangular Countertop Deck with Integral Ramp Basin, Two Station <**Insert drawing designation**>:
   a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
   b. Fixture:
      1) Standard: CSA B45.8/IAPMO Z403 and ICC A117.1.
      2) Type: Straight front and side aprons with straight back.
      3) Overall Countertop size: [**68 by 22 by 5 inches**] <Insert dimension>.
      4) Basin I.D.: [**48 by 13 by 5 inches**] [**50 by 12 by 5 inches**] [**50 by 13 by 5 inches**] [**60 by 13 by 5 inches**].
      5) Faucet-Hole Punching (per Station): [Zero holes] [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers] <Insert hole pattern>.
      6) Faucet-Hole Location: [**Top**] [**Wall mount**].
      7) Drain Type: Slot drain.
      8) Color: [White linen] [Concrete] [Charcoal] [Limestone] [Graphite] [Pewter] [Dusk] [Taupe] <Insert color>.
      9) Mounting Material: Concrete sink steel base.
   c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
   d. Waste Fittings:
      1) Standard: ASME A112.18.2/CSA B125.2.
      2) Type: 1-1/2-inch slip joint connection.
      3) Finish: [Polished chrome] [Brushed nickel] [Oil-rubbed bronze].
   e. Support: Concrete sink steel base.
   f. Lavatory Height: Accessible in accordance with ICC A117.1.
2. Lavatories, Freestanding - Precast GFRC, Rectangular Countertop Deck with Integral Ramp Basin, Three Station <**Insert drawing designation**>:
   a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
   b. Fixture:
      1) Standard: CSA B45.8/IAPMO Z403 and ICC A117.1.
      2) Type: Straight front and side aprons with straight back.
      3) Overall Countertop Size: [**72 by 22 by 5 inches**] [**84 by 22 by 5 inches**] [**98 by 22 by 5 inches**] <Insert dimension>.
      4) Basin I.D.: [**60 by 13 by 5 inches**] [**72 by 13 by 5 inches**] [**80 by 12 by 5 inches**] [**84 by 12 by 5 inches**].
      5) Faucet-Hole Punching (per Station): [Zero holes] [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers] <Insert hole pattern>.
      6) Faucet-Hole Location: [**Top**] [**Wall mount**].
      7) Drain Type: Slot drain.
      8) Color: [White linen] [Concrete] [Charcoal] [Limestone] [Graphite] [Pewter] [Dusk] [Taupe] <Insert color>.
      9) Mounting Material: Concrete sink steel base.
   c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
   d. Waste Fittings:
      1) Standard: ASME A112.18.2/CSA B125.2.
      2) Type: 1-1/2-inch slip joint connection.
      3) Finish: [Polished chrome] [Brushed nickel] [Oil-rubbed bronze].

e. Support: Manufacturer's concrete sink steel base.
f. Lavatory Height: Accessible in accordance with ICC A117.1.

3. Lavatories, Freestanding - Precast GFRC, Rectangular Countertop Deck with Integral Ramp Basin, Four Station <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Fixture:
1) Standard: CSA B45.8/IAPMO Z403 and ICC A117.1.
2) Type: Straight front and side aprons with straight back.
3) Overall Countertop Size: [**107 by 22 by 5 inches**] [**128 by 22 by 5 inches**] <Insert dimension>.
4) Basin I.D.: [**96 by 12 by 5 inches**] [**110 by 12 by 5 inches**].
5) Faucet-Hole Punching (per Station): [Zero holes] [One hole] [Three holes, **2-inch** centers] [Three holes, **4-inch** centers] <Insert hole pattern>.
6) Faucet-Hole Location: [**Top**] [**Wall mount**].
7) Drain Type: Slot drain.
8) Color: [White linen] [Concrete] [Charcoal] [Limestone] [Graphite] [Pewter] [Dusk] [Taupe] <Insert color>.
9) Mounting Material: Concrete sink steel base.
c. Faucet: <Insert lavatory faucet designation from "Lavatory Faucets, Manually Operated" or "Lavatory Faucets, Automatically Operated" Paragraph>.
d. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Type: 1-1/2-inch slip joint connection.
3) Finish: [Polished chrome] [Brushed nickel] [Oil-rubbed bronze].
e. Support: Manufacturer's concrete sink steel base.
f. Lavatory Height: Accessible in accordance with ICC A117.1.

D. Lavatory Systems:
1. Lavatory Systems - Single or Multiple Stations <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain lavatory systems from single source from single manufacturer.
c. Standards:
1) ASME A112.18.1/CSA B125.1.
2) CSA B45.5/IAPMO Z124.
3) NSF 61.
4) NSF 372.
5) UPC, IPC, and GREENGUARD Certified.
d. 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.
e. Bowl(s) and Counter:
1) Material: Solid-surface or natural quartz surface.
2) Height to Rim: [Standard] [Accessible in accordance with ICC A117.1] <Insert height>.
3) Color or Finish: [Not applicable] <Insert if required>.
4) Access Panel: 16-1/8-inch access panel.

5) Number of Bowls or User Stations: [**One**] [**Two**] [**Three**] [**Four**] <**Insert number**>.
6) Bowl Shape: [Trough] [Oval] [Round] [Square] [Rectangular] <Insert shape>.
7) Drain: Grid with NPS 1-1/2 tailpiece, each bowl.

f. Pedestal: [Not required] [Required, with access panel].
g. Faucets:
1) Type: Manufacturer's standard, chrome-plated solid brass, each bowl/station.
2) Control: [Manual, push-button] [Hardwired, control-voltage, sensor-actuated] [Battery-powered, sensor-actuated] <Insert type> actuation with [pressure-balancing] [thermostatic] mixing valve with check stops for each bowl or user station.
h. Mixer Point-of-Use:
1) Material: Solid bimetal (bronze, brass, stainless steel).
2) Security: Hot limit stop set to a maximum of 109.4 deg F.
3) Set: Screwdriver adjustment temperature dial with scale: Cold-hot.
4) Operation: Electronic "no-touch" hardwired powered.
5) Power: 120 V ac.
i. High-Speed, Warm-Air Hand Dryer:
1) Dryer Mounting: [Surface mounted][, with low-profile design].
2) Operation: Electronic-sensor activated with operation time of [**10 to 20**] <**Insert number(s)**> seconds.
3) Cover Material and Finish: [Chrome-plated steel] <Insert material and finish>.
4) Electrical Requirements: [115 V, 13 A, 1500 W] [115 V, 15 A, 1725 W] [115 V, 20 A, 2300 W] [208-240 V, 9-10 A, 1900-2300 W] <Insert electrical requirements>.
j. Liquid-Soap Dispensers: [Hardwired, sensor actuated] [Battery powered, sensor actuated] [Not required], for each bowl or user station.
k. Mounting: [Manufacturer's wall-mounting bracket] [and/or] [commercial floor-mounted carrier] <Insert type>.
l. Supply Fittings:
1) Piping: NPS 1/2 copper tubing, each bowl.
2) Valves: Shutoff valve on each supply.
3) Supply Piping: From wall.
m. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Trap and Drain Piping: NPS 1-1/2, each bowl.

E. Lavatory Faucets, Manually Operated <**Insert drawing designation**>:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Standard: ASME A112.18.1/CSA B125.1.
3. Operation Type: [Single control, mixing] [Single control, nonmixing] [Two handle, mixing], [Commercial] [General duty].
4. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
5. Body Type: [Centerset] [Widespread] [Single hole] <Insert type>.
6. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.

7. Finish: [Polished chrome plate] <Insert finish>.
8. Maximum Flow Rate: [**0.5 gpm**] <Insert value>.
9. Maximum Flow: [**0.25 gal.**] <**Insert value**> per metering cycle.
10. Mounting Type: [Deck, exposed] [Deck, concealed] [Back/wall, exposed] [Back/wall, concealed].
11. Valve Handle(s): [Single lever] [Knob] [Knob, nonmetallic] [Cross, three arm] [Cross, four arm] [Wrist blade, **4 inches**] [Elbow, **6 inches**] [Push button] <Insert type>.
12. Spout: [Rigid] [Swing] [Rigid, gooseneck] [Swivel, gooseneck] type.
13. Spout Outlet: [Aerator] [Laminar flow] [Spray] <Insert type>.
14. Operation: [Compression, manual] [Noncompression, manual].
15. Drain: [Not part of faucet] <Insert type>.

F. Lavatory Faucets, Automatically Operated <**Insert drawing designation**>:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Standards: ASME A112.18.1/CSA B125.1 and UL 1951.
3. Operation Type: [**Battery powered**] [**Hardwired**] electronic sensor operated, [**mixing**] [**nonmixing**].
4. 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.
5. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
6. Body Type: [Single hole] <Insert type>.
7. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
8. Finish: [Polished chrome plate] <Insert finish>.
9. Maximum Flow Rate: [**0.5 gpm**] <Insert value>.
10. Mounting Type: [Deck, concealed] [Back/wall, concealed] <Insert type>.
11. Spout: [Rigid] [Swing] [Rigid, gooseneck] [Swivel, gooseneck] type.
12. Spout Outlet: [Aerator] [Laminar flow] [Spray] <Insert type>.
13. Drain: [Not part of faucet] <Insert type>.

G. Lavatory Supply Fittings:
1. NSF Standard: Comply with NSF 61 and NSF 372 for supply-fitting materials that will be in contact with potable water.
2. Standard: ASME A112.18.1/CSA B125.1.
3. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless steel wall flange.
4. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
5. Operation: [Loose key] [Wheel handle] <Insert type>.
6. Risers:
   a. [**NPS 3/8**] [**NPS 1/2**].
   b. [Chrome-plated, rigid-copper-pipe and brass straight or offset tailpieces] [Chrome-plated, soft-copper flexible tube] [ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel, flexible hose] riser.

H. Lavatory Waste Fittings:
1. Standard: ASME A112.18.2/CSA B125.2.
2. Drain: Grid type with NPS 1-1/4 offset and straight tailpiece.
3. Trap:

a. Size: [**NPS 1-1/2 by NPS 1-1/4**] [**NPS 1-1/4**].
b. Material:
1) Chrome-plated, [two-piece, cast-brass trap and swivel elbow with **0.032-inch-**thick brass tube to wall] [two-piece, cast-brass trap and ground-joint swivel elbow with **0.032-inch-**thick brass tube to wall] [one-piece, cast-brass trap with swivel **0.029-inch-**thick tubular brass wall bend] <Insert trap type>; and chrome-plated, brass or steel wall flange.
2) Stainless steel, two-piece trap and swivel elbow with 0.012-inch thick stainless steel tube to wall, and stainless steel wall flange.

2.03 COMMERCIAL SHOWERS

A. Showers, Individual:
1. Showers, Individual - FRP, One Piece without Top <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain FRP showers without top from single source from single manufacturer.
c. Description: FRP shower enclosure with valve and receptor[**and appurtenances**].
d. Standard: CSA B45.5/IAPMO Z124.
e. Style: [Standard] [Accessible in accordance with ICC A117].
f. Shower Head and Shower Valve: <Insert shower head and shower valve designation from "Shower Valve Assemblies" Paragraph>.
g. Shower Nominal Size and Shape: [**30 by 30 inches** square] [**32 by 32 inches** square] [**34 by 34 inches** square] [**36 by 36 inches** square] [**48 by 36 inches** rectangular] [**60 by 36 inches** rectangular] [**36 inches** neo-corner (two walls)] [**36 inches** neo-corner (four walls)] [**38 inches** neo-corner (two walls)] [**38 inches** neo-corner (four walls)] [**42 inches** neo-corner (two walls)] [**42 inches** neo-corner (four walls)] <Insert dimensions>.
h. Color: [White] <Insert color>.
i. Outlet: Drain with [**NPS 2**] <**Insert pipe size**> outlet.
j. Shower Rod and Curtain: [**Not required**] [**Required**].
k. Grab Bar: [ASTM F446, mounted on support area back wall] [Not required].
2. Showers, Individual - FRP, Sectional without Top <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain FRP showers without top from single source from single manufacturer.
c. Description: FRP shower enclosure with valve and receptor[**and appurtenances**].
d. Standard: CSA B45.5/IAPMO Z124.
e. Style: [Standard] [Accessible in accordance with ICC A117.1].
f. Shower Head and Shower Valve: <Insert shower head and shower valve designation from "Shower Valve Assemblies" Paragraph>.
g. Shower Nominal Size and Shape: [**30 by 30 inches** square] [**32 by 32 inches** square] [**34 by 34 inches** square] [**36 by 36 inches** square] [**48 by 36 inches** rectangular] [**60 by 36 inches** rectangular] [**36 inches** neo-corner (two walls)] [**36 inches** neo-corner (four walls)] [**38 inches** neo-corner (two walls)] [**38 inches** neo-corner (four walls)] [**42 inches** neo-corner (two walls)] [**42 inches** neo-corner (four walls)] <Insert dimensions>.
h. Color: [White] <Insert color>.
i. Outlet: Drain with [**NPS 2**] <**Insert pipe size**> outlet.

j. Shower Rod and Curtain: [**Not required**] [**Required**].
k. Grab Bar: [ASTM F446, mounted on support area back wall] [Not required].

3. Showers, Individual - PMMA <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain PMMA showers from single source from single manufacturer.
c. Description: PMMA shower enclosure with valve and receptor[**and appurtenances**].
d. Type: [One-piece] [Sectional].
e. Standard: CSA B45.5/IAPMO Z124.
f. Style: [Standard] [Accessible in accordance with ICC A117.1].
g. Shower Head and Shower Valve: <Insert shower head and shower valve designation from "Shower Valve Assemblies" Paragraph>.
h. Shower Nominal Size and Shape: [**30 by 30 inches** square] [**32 by 32 inches** square] [**34 by 34 inches** square] [**36 by 36 inches** square] [**48 by 36 inches** rectangular] [**60 by 36 inches** rectangular] [**36 inches** neo-corner (two walls)] [**36 inches** neo-corner (four walls)] [**38 inches** neo-corner (two walls)] [**38 inches** neo-corner (four walls)] [**42 inches** neo-corner (two walls)] [**42 inches** neo-corner (four walls)] <Insert dimensions>..
i. Color: [White] <Insert color>.
j. Outlet: Drain with [**NPS 2**] <**Insert pipe size**> outlet.
k. Shower Rod and Curtain: [**Not required**] [**Required**].
l. Grab Bar: [ASTM F446, mounted on support area back wall] [Not required].

4. Showers, Individual - Cabinet <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain cabinet showers from single source from single manufacturer.
c. Description: Factory-fabricated[**, accessible**] cabinet shower, with valve and receptor.
d. Nominal Size: [**30 by 30 inches**] [**32 by 32 inches**] [**36 by 36 inches**] [**36 by 39 inches**] [**45 by 39 inches**] <Insert dimensions>.
e. Material: [Steel] [Stainless steel] [Composite] [Plastic].
f. Access: [Front] [Corner] [Front and rear] access.
g. Color: [Not applicable] <Insert color>.
h. Accessibility Options: Grab bar and bench.
i. Shower Head and Shower Valve: [Manufacturer's standard fitting assembly] <Insert shower head and shower valve designation from "Shower Valve Assemblies" Paragraph>.
j. Supplies: NPS 1/2 copper tubing[**with ball, gate, or globe valves**].
k. Drain: Grid, NPS 2.

B. Shower Valve Assemblies:
1. Shower Valve Assemblies - Single-Handle, Pressure-Balanced Mixing Valve with Head <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain shower heads and shower valves from single source from single manufacturer.

c. Description: Single-handle, [**accessible,**]pressure-balance mixing valve with hot- and cold-water indicators; [**diverting valve**]check stops; and [**hose with handheld shower head**] [**hose with handheld shower head on sliding rod**] shower head.

d. Shower Valve:
   1) Standards:
      a) ASME A112.18.1/CSA B125.1.
      b) ASSE 1016/ASME A112.1016/CSA B125.16.
   2) Body Material: Solid brass.
   3) Finish: [Polished chrome plate] <Insert finish>.
   4) Mounting: [**Concealed**] [**Exposed**].
   5) Operation: Single-handle, [**push-pull**] [**or**] [**twist or rotate**] [**or**] [**metering**] control.
   6) Antiscald Device: [Integral with mixing valve] [Separate unit] [Not required].
   7) Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.

e. Supply Connections: NPS 1/2.

f. Shower Head:
   1) Standard: ASME A112.18.1/CSA B125.1.
   2) Type: [Ball joint with arm and flange] [Without ball joint, but with arm and flange] [Ball joint and head integral with mounting flange] [Integral with mounting flange] <Insert type>.
   3) EPA WaterSense: Required.
   4) Shower Head Maximum Flow Rate: [**1.5 gpm**] [**1.75 gpm**] [**2.0 gpm**] [**2.5 gpm**].
   5) Shower Head Material: Metallic with chrome-plated finish.
   6) Spray Pattern: [**Adjustable**] [**Fixed**].
   7) Integral Volume Control: [**Not required**] [**Required**].
   8) Temperature Indicator: [Integral with shower valve] [Not required].

2. Shower Valve Assemblies - Single-Handle, Thermostatic Mixing Valve with Head <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Source Limitations: Obtain shower heads and shower valves from single source from single manufacturer.

c. Description: Single-handle, [**accessible,**]thermostatic mixing valve with hot- and cold-water indicators; [**diverting valve**]check stops; and [**hose with handheld shower head**] [**hose with handheld shower head on sliding rod**] shower head.

d. Shower Valve:
   1) Standards:
      a) ASME A112.18.1/CSA B125.1.
      b) ASSE 1016/ASME A112.1016/CSA B125.16.
   2) Body Material: Solid brass.
   3) Finish: [Polished chrome plate] <Insert finish>.
   4) Mounting: [**Concealed**] [**Exposed**].
   5) Operation: Single-handle, [**push-pull**] [**or**] [**twist or rotate**] control.
   6) Antiscald Device: [Integral with mixing valve] [Separate unit] [Not required].
   7) Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.

e. Supply Connections: NPS 1/2.
f. Shower Head:
1) Standard: ASME A112.18.1/CSA B125.1.
2) Type: [Ball joint with arm and flange] [Without ball joint, but with arm and flange] [Ball joint and head integral with mounting flange] [Integral with mounting flange] <Insert type>.
3) EPA WaterSense: Required.
4) Shower Head Maximum Flow Rate: [**1.5 gpm**] [**1.75 gpm**] [**2.0 gpm**] [**2.5 gpm**].
5) Shower Head Material: Metallic with chrome-plated finish.
6) Spray Pattern: [**Adjustable**] [**Fixed**].
7) Integral Volume Control: [**Not required**] [**Required**].
8) Temperature Indicator: [Integral with valve] [Not required].

3. Shower Valve Assemblies - Single-Handle, Thermostatic/Pressure-Balancing Mixing Valve with Head <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain shower heads and shower valves from single source from single manufacturer.
c. Description: Single-handle, [**accessible,**]thermostatic/pressure-balancing mixing valve with hot- and cold-water indicators; [**diverting valve**]check stops; and [**hose with handheld shower head**] [**hose with handheld shower head on sliding rod**]shower head.
d. Shower Valve:
1) Standards:
a) ASME A112.18.1/CSA B125.1.
b) ASSE 1016/ASME A112.1016/CSA B125.16.
2) Body Material: Solid brass.
3) Finish: [Polished chrome plate] <Insert finish>.
4) Mounting: [**Concealed**] [**Exposed**].
5) Operation: Single-handle, [**push-pull**] [**or**] [**twist or rotate**] control.
6) Antiscald Device: [Integral with mixing valve] [Separate unit] [Not required].
7) Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
e. Supply Connections: NPS 1/2.
f. Shower Head:
1) Standard: ASME A112.18.1/CSA B125.1.
2) Type: [Ball joint with arm and flange] [Without ball joint, but with arm and flange] [Ball joint and head integral with mounting flange] [Integral with mounting flange] <Insert type>.
3) EPA WaterSense: Required.
4) Shower Head Maximum Flow Rate: [**1.5 gpm**] [**1.75 gpm**] [**2.0 gpm**] [**2.5 gpm**].
5) Shower Head Material: Metallic with chrome-plated finish.
6) Spray Pattern: [**Adjustable**] [**Fixed**].
7) Integral Volume Control: [**Not required**] [**Required**].
8) Temperature Indicator: [Integral with valve] [Not required].

C. Shower Basins:
1. Shower Basins - Cast Polymer <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain shower basins from single source from single manufacturer.
c. Description: Cast-polymer base for built-up-type shower fixture.
d. Standard: CSA B45.5/IAPMO Z124.
e. Type: [Standard] [Accessible in accordance with ICC A117.1].
f. Nominal Size and Shape: [**30 by 30 inches** square] [**32 by 32 inches** square] [**34 by 34 inches** square] [**36 by 36 inches** square] [**42 by 34 to 36 inches** rectangular] [**48 by 34 to 36 inches** rectangular] [**36 inches** neo-corner] [**42 inches** neo-corner] <Insert dimensions>.
g. Color: [White] <Insert color>.
h. Outlet: Drain with [**NPS 2**] <Insert pipe size> outlet[; lip drain outside shower in accordance with ADA-ABA].

2. Shower Basins - FRP <Insert drawing designation>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain shower basins from single source from single manufacturer.
c. Description: FRP base for built-up-type shower fixture.
d. Standard: CSA B45.5/IAPMO Z124.
e. Type: [Standard] [Accessible in accordance with ICC A117.1].
f. Nominal Size and Shape: [**30 by 30 inches** square] [**32 by 32 inches** square] [**34 by 34 inches** square] [**36 by 36 inches** square] [**42 by 34 to 36 inches** rectangular] [**48 by 34 to 36 inches** rectangular] [**36 inches** neo-corner] [**42 inches** neo-corner] <Insert dimensions>.
g. Color: [White] <Insert color>.
h. Outlet: Drain with [**NPS 2**] <Insert pipe size> outlet[; lip drain outside shower in accordance with ADA-ABA].

3. Shower Basins - PMMA <Insert drawing designation>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain shower basins from single source from single manufacturer.
c. Description: PMMA base for built-up-type shower fixture.
d. Standard: CSA B45.5/IAPMO Z124.
e. Type: [Standard] [Accessible in accordance with ICC A117.1].
f. Nominal Size and Shape: [**30 by 30 inches** square] [**32 by 32 inches** square] [**36 by 36 inches** square] [**42 by 34 to 36 inches** rectangular] [**48 by 34 to 36 inches** rectangular] [**36 inches** neo-corner] [**42 inches** neo-corner] <Insert dimensions>.
g. Color: [White] <Insert color>.
h. Outlet: Drain with [**NPS 2**] <Insert pipe size> outlet[; lip drain outside shower in accordance with ADA-ABA].

4. Shower Basins - Molded Stone <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain shower basins from single source from single manufacturer.

c. Description: Molded-stone base for built-up-type shower fixture.
d. Standard: CSA B45.8/IAPMO Z403.
e. Type: [Standard] [Accessible in accordance with ICC A117.1].
f. Nominal Size and Shape: [**30 by 30 inches** square] [**32 by 32 inches** square] [**36 by 36 inches** square] [**42 by 34 to 36 inches** rectangular] [**48 by 34 to 36 inches** rectangular] [**36 inches** neo-corner] [**42 inches** neo-corner] <Insert dimensions>.
g. Color: [White] <Insert color>.
h. Outlet: Drain with [**NPS 2**] <Insert pipe size> outlet[; lip drain outside shower in accordance with ADA-ABA].

5. Shower Basins - Precast Terrazzo <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain shower basins from single source from single manufacturer.
c. Description: Precast-terrazzo base for built-up-type shower fixture.
d. Standard: CSA B45.8/IAPMO Z403.
e. Type: [Standard] [Accessible in accordance with ICC A117.1].
f. Nominal Size and Shape: [**30 by 30 inches** square] [**32 by 32 inches** square] [**36 by 36 inches** square] [**42 by 34 to 36 inches** rectangular] [**48 by 34 to 36 inches** rectangular] [**36 inches** neo-corner] [**42 inches** neo-corner] <Insert dimensions>.
g. Color: [White] <Insert color>.
h. Outlet: Drain with [**NPS 2**] <Insert pipe size> outlet[; lip drain outside shower in accordance with ADA-ABA].

6. Shower Basins - Solid Surface <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain shower basins from single source from single manufacturer.
c. Description: Solid-surface base for built-up-type shower fixture.
d. Standard: CSA B45.5/IAPMO Z124.
e. Type: [Standard] [Accessible in accordance with ICC A117.1].
f. Nominal Size and Shape: [**30 by 30 inches** square] [**32 by 32 inches** square] [**36 by 36 inches** square] [**42 by 34 to 36 inches** rectangular] [**48 by 34 to 36 inches** rectangular] [**36 inches** neo-corner] [**42 inches** neo-corner] <Insert dimensions>.
g. Color: [White] <Insert color>.
h. Outlet: Drain with [**NPS 2**] <Insert pipe size> outlet[; lip drain outside shower in accordance with ADA-ABA].

D. Showers, Group:
1. Showers, Group - Column <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain showers from single source from single manufacturer.
c. Description: Stainless steel, column shower fixture with individual nozzles.
d. Standards:
1) ASME A112.18.1/CSA B125.1.
2) ASSE 1016/ASME A112.1016/CSA B125.16.

e. Metal Nominal Thickness: [**0.050 inch** minimum] [**0.063 inch**].
f. Number of Shower Nozzles: [**Two**] [**Three**] [**Four**] [**Five**] [**Six**].
g. Height to Nozzles: [**66 inches**] [**72 inches**] [**78 inches**] <Insert dimension>.
h. Control:
1) [**Thermostatic**] [**Pressure-balance**] mixing valve with hot and cold-water operation.
2) Thermostatic mixing valve with individual, tempered-water supply and push-button operation.
i. Shower-Arm, Flow-Control Fitting: [Not required] [**1.5 gpm**] [**2.0 gpm**] [**2.5 gpm**] for each shower head.
j. EPA WaterSense: Required.
k. Liquid Soap Dispenser: [**Not required**] [**Required**] for each shower head.
l. Soap Dish: [**Not required**] [**Required**] for each shower head.
m. Mounting: Floor flange.
n. Supplies: [**NPS 3/4**] [**NPS 1**] copper tubing with shutoff valve from [**bottom**] [**top**].
o. Shroud: [Not required] [Stainless steel of size to cover supplies and vent piping].
p. Drain Fitting: [**NPS 3**] [**NPS 4**] outlet with NPS 2 vent, integral with base of column.

2. Showers, Group - Wall Mounted <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain showers from single source from single manufacturer.
c. Description: Stainless steel, wall-mounted, surface-enclosure shower fixture with individual nozzles.
d. Standards:
1) ASME A112.18.1/CSA B125.1.
2) ASSE 1016/ASME A112.1016/CSA B125.16.
e. Metal Nominal Thickness: [**0.050 inch** minimum] [**0.063 inch**].
f. Number of Shower Nozzles: [**Two**] [**Three**].
g. Height to Nozzles: [**66 inches**] [**72 inches**] <Insert dimension>.
h. Control:
1) [**Thermostatic**] [**Pressure-balance**] valve with individual hot- and cold-water mixing-valve operation.
2) Thermostatic valve with individual, tempered-water supply and push-button operation.
i. Flow-Control Fitting: [Not required] [**1.5 gpm**] [**2.0 gpm**] [**2.5 gpm**] for each shower head.
j. EPA WaterSense: Required.
k. Liquid Soap Dispenser: [**Not required**] [**Required**] for each shower head.
l. Soap Dish: [**Not required**] [**Required**] for each shower head.
m. Mounting: Wall bracket.
n. Supplies: NPS 3/4 copper tubing with valves.

E. Showers, Outdoor:
1. Showers, Outdoor - Plastic <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain showers from single source from single manufacturer.
c. Description: Freestanding, plastic group-shower fixture.
d. Number of Shower Stations: [**One**] [**Two**] [**Three**] [**Four**] <**Insert number up to six**> with individual, self-closing control valve(s).

e. Nozzles: With adjustable spray pattern; fixed, on column.
f. Control: Push button and timer.
g. Maximum Flow: 2.5 gpm for each shower head.
h. Number of Foot-Wash Stations: [**One**] [**Two**] <**Insert number**> with individual, self-closing control valve(s).
i. Hose Bibb: [**Not**] [**One**] required.
j. Control-Valve Mounting Height: [**50 inches**] [**48 inches**].
k. Material: Cast-filled-polymer plastic.
l. Color: [Gray] <Insert color>.
m. Internal Piping: Factory installed.
n. Mounting: Base flange with bolt holes.

2. Showers, Outdoor - Steel <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain showers from single source from single manufacturer.
c. Description: Freestanding, steel, group-shower fixture.
d. Number of Shower Stations: [**Four or more**] <**Insert value**> with individual, self-closing control valve(s).
e. Nozzles: Fixed, on column.
f. Control: Push button and timer.
g. Maximum Flow: 2.5 gpm for each shower head.
h. Flow-Control Fitting: [Not required] [**1.5 gpm**] [**2.0 gpm**] [**2.5 gpm**] for each shower head.
i. EPA WaterSense: Required.
j. Number of Foot-Wash Stations: [**Not required**] [**One**] [**Two**] with individual, self-closing control valve(s).
k. Material: [Powder-coated steel] [Stainless steel].
l. Color: [Blue] <Insert color>.
m. Internal Piping: Factory installed.
n. Mounting: Base flange with bolt holes.

F. Grout:
1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink; recommended for interior and exterior applications.
3. Design Mix: 5000 psi, 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

2.04 COMMERCIAL SINKS

A. Service Sinks, Floor Mounted:
1. Service Sinks, Floor Mounted - Terrazzo <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain sinks from single source from single manufacturer.
c. Fixture:
1) Material: Marble chips cast in portland cement to produce a compressive strength of not less than 3000 psi, seven days after casting.
2) Shape: [Square] [Rectangular] [Five sided] [Radial front] <Insert shape>.
3) Nominal Size: [**24 by 24 inches**] [**30 by 30 inches**] [**24 by 36 inches**] [**32 by 32 inches**] [**36 by 36 inches**] <Insert dimensions>.

4) Height: [**6 inches**] [**10 inches**] [**12 inches**] [**12 inches** with dropped front] <Insert dimensions>.
5) Tiling Flange: [Not required] [On one side] [On two sides] [On three sides].
6) Rim Guard: On [**front**] [**all**] top surfaces.
7) Color: [Not applicable] <Insert color>.
8) Drain: Grid with [**NPS 2**] [**NPS 3**] outlet.

d. Mounting: On floor and flush to wall.
e. Faucet: <Insert service sink faucet designation from "Sink Faucets, Manually Operated" Paragraph>.

2. Service Sinks, Floor Mounted - Plastic <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain sinks from single source from single manufacturer.
c. Fixture:
1) Standard: CSA B45.5/IAPMO Z124.
2) Material: [Molded polymer] <Insert material>.
3) Nominal Size: [**24 by 36 by 10 inches**] [**36 by 36 by 10 inches**] <Insert dimensions>.
4) Rim Guard: On [**front**] [**all**] top surfaces.
5) Color: [Not applicable] <Insert color>.
6) Drain: Grid with [**NPS 2**] [**NPS 3**] outlet.
d. Mounting: On floor and flush to wall.
e. Faucet: <Insert service sink faucet designation from "Sink Faucets, Manually Operated" Paragraph>.

3. Service Sinks, Floor Mounted - Molded Stone <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain sinks from single source from single manufacturer.
c. Fixture:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Shape: [Square] [Rectangular] <Insert shape>.
3) Nominal Size: [**24 by 24 inches**] [**24 by 36 inches**] <Insert dimensions>.
4) Height: [**10 inches**] <Insert dimensions>.
5) Rim Guard: On [**front**] [**all**] top surfaces.
6) Color: [Not applicable] <Insert color>.
7) Drain: Grid with [**NPS 2**] [**NPS 3**] outlet.
d. Mounting: On floor and flush to wall.
e. Faucet: <Insert service sink faucet designation from "Sink Faucets, Manually Operated" Paragraph>.

4. Service Sinks, Floor Mounted - Enameled Cast Iron <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain sinks from single source from single manufacturer.
c. Fixture:
1) Standard: ASME A112.19.1/CSA B45.2.
2) Style: With front apron and raised back.
3) Nominal Size: 28 by 28 inches.
4) Color: White.
5) Drain: Grid with [**NPS 2**] [**NPS 3**] outlet.

6) Rim Guard: Coated wire.

d. Faucet: <Insert service sink faucet designation from "Sink Faucets, Manually Operated" Subparagraph>.

B. Service Sinks, Trap Standard Mounted:

1. Service Sinks, Trap Standard Mounted - Enameled Cast Iron <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Source Limitations: Obtain sinks from single source from single manufacturer.

c. Fixture:

1) Standard: ASME A112.19.1/CSA B45.2.

2) Type: Service sink with back.

3) Back: [Two faucet holes] [Plain].

4) Nominal Size: [**22 by 18 inches**] [**24 by 20 inches**].

5) Color: White.

6) Mounting: [**NPS 2**] [**NPS 3**] P-trap standard with grid strainer inlet, cleanout, and floor flange.

7) Rim Guard: On front and sides.

d. Faucet: <Insert service sink faucet designation from "Sink Faucets, Manually Operated" Paragraph>.

e. Support: [Sink carrier] <Insert carrier>.

C. Kitchen/Utility Sinks:

1. Kitchen/Utility Sinks, Counter Mounted - Stainless Steel <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Source Limitations: Obtain sinks from single source from single manufacturer.

c. Fixture:

1) Standard: ASME A112.19.3/CSA B45.4.

2) Type: Stainless steel, self-rimming, sound-deadened unit [**less ledge back**] [**with ledge back**].

3) Number of Compartments: [**One**] [**Two**] [**Three**].

4) Overall Dimensions: <**Insert dimensions**>.

5) Material: 18 gauge, Type 304 stainless steel.

6) Compartment:

a) Dimensions: <Insert dimensions>.

b) Drain: [Grid with **NPS 1-1/2** tailpiece and twist drain] [Grid with **NPS 2** tailpiece and twist drain] [**NPS 1-1/2** tailpiece with stopper] <Insert drain>.

c) Drain Location: [Centered in compartment] [Near back of compartment] [Near left side of compartment] [Near right side of compartment] <Insert location>.

d) Depth: [Standard] [Accessible in accordance with ICC A117.1].

7) Each Compartment:

a) Dimensions: <Insert dimensions>.

b) Drains: [Grid with **NPS 1-1/2** tailpiece and twist drain] [Grid with **NPS 2** tailpiece and twist drain] [**NPS 1-1/2** tailpiece with stopper] <Insert drain>.

c) Drain Location: [Centered in compartment] [Near back of compartment] <Insert location>.
d) Depth: [Standard] [Accessible in accordance with ICC A117.1].

d. Faucet(s): <Insert sink faucet designation from "Sink Faucets, Manually Operated" or "Sink Faucets, Automatically Operated" Subparagraph>.
1) Number Required: [**One**] [**Two**].
2) Mounting: On ledge.

e. Supply Fittings:
1) Standard: ASME A112.18.1/CSA B125.1.
2) Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.
a) Operation: [Loose key] [Wheel handle] <Insert type>.
b) Risers: NPS 1/2, [chrome-plated, rigid-copper pipe] [chrome-plated, soft-copper flexible tube] [ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel flexible hose].

f. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Trap(s) Size: [**NPS 1-1/2**] [**NPS 2**].
3) Trap(s) Material:
a) Chrome-plated, [two-piece, cast-brass trap and swivel elbow with 17-gauge brass tube to wall] [two-piece, cast-brass trap and ground-joint swivel elbow with 17-gauge brass tube to wall] <Insert trap type>; and chrome-plated brass or steel wall flange.
b) Stainless steel, two-piece trap and swivel elbow with 0.012-inch-thick stainless steel tube to wall; and stainless steel wall flange.
4) Continuous Waste:
a) Size: [**NPS 1-1/2**] [**NPS 2**].
b) Material: Chrome-plated, 17-gauge brass tube.

g. Mounting: On counter with sealant.

2. Kitchen/Utility Sinks, Freestanding - Stainless Steel <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain sinks from single source from single manufacturer.
c. Fixture:
1) Standards:
a) ASME A112.19.3/CSA B45.4.
b) [NSF 2].
2) Type: Stainless steel, freestanding, sound-deadened unit with backsplash.
3) Number of Compartments: [**One**] [**Two**] [**Three**] [**Four**].
4) Overall Dimensions: <**Insert dimensions**>.
5) Material: [**14**] [**16**] gauge, Type 304 stainless steel.
6) Compartment:
a) Dimensions: <Insert dimensions>.
b) Drain: [Grid with **NPS 1-1/2** tailpiece and twist drain] [Grid with **NPS 2** tailpiece and twist drain] [**NPS 1-1/2** tailpiece with stopper] <Insert drain>.
c) Drain Location: [Centered in compartment] [Near back of compartment] [Near left side of compartment] [Near right side of compartment] <Insert location>.

7) Each Compartment:
a) Dimensions: <Insert dimensions>.
b) Drains: [Grid with **NPS 1-1/2** tailpiece and twist drain] [Grid with **NPS 2** tailpiece and twist drain] [**NPS 1-1/2** tailpiece with stopper] <Insert drain>.
c) Drain Location: [Centered in compartment] [Near back of compartment] <Insert location>.
8) Integral Drainboard(s): [**Not required**] [**Both**] [**Left**] [**Right**] side(s).
a) Dimensions Each: [Not applicable] <Insert dimensions>.

d. Legs and Feet: Stainless steel tubing legs with adjustable bullet feet.
e. Faucet(s): <Insert sink faucet designation from "Sink Faucets, Manually Operated" or "Sink Faucets, Automatically Operated" Paragraph>.
1) Number Required: [**One**] [**Two**].
2) Mounting: On backsplash.
f. Supply Fittings:
1) Standard: ASME A112.18.1/CSA B125.1.
2) Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.
a) Operation: [Loose key] [Wheel handle] <Insert type>.
b) Risers: NPS 1/2, [chrome-plated, rigid-copper pipe] [chrome-plated, soft-copper flexible tube] [ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel flexible hose].
g. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Trap(s) Size: [**NPS 1-1/2**] [**NPS 2**].
3) Trap(s) Material:
a) Chrome-plated, [two-piece, cast-brass trap and swivel elbow with 17-gauge brass tube to wall] [two-piece, cast-brass trap and ground-joint swivel elbow with 17-gauge brass tube to wall] <Insert trap type>; and chrome-plated brass or steel wall flange.
b) Stainless steel, two-piece trap and swivel elbow with 0.012-inch-thick stainless steel tube to wall; and stainless steel wall flange.
4) Continuous Waste:
a) Size: [**NPS 1-1/2**] [**NPS 2**].
b) Material: Chrome-plated, 17-gauge brass tube.

D. Handwash Sinks:
1. Handwash Sinks - Stainless Steel <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain sinks from single source from single manufacturer.
c. Fixture:
1) Standards:
a) ASME A112.19.3/CSA B45.4.
b) NSF 61.
2) Type: [**Wall-mounted**] [**Pedestal-base**] stainless steel basin with radius corners, back for faucet, and support brackets.
3) Overall Dimensions: [**17 by 16 by 5 inches**] <Insert dimensions>.
4) Material: [**18 gauge**] [**20 gauge**] <**Insert gauge**>, Type 304 stainless steel.

d. Faucet: <Insert sink faucet designation from "Sink Faucets, Manually Operated" or "Sink Faucets, Automatically Operated" Paragraph>.
e. Supply Fittings: Comply with requirements in "Sink Supply Fittings" Paragraph.
f. Waste Fittings: Comply with requirements in "Sink Waste Fittings" Paragraph.
g. Support: [Sink carrier, framing affixed] [Sink carrier, floor affixed with steel uprights] <Insert carrier>.
h. Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

E. Sacristy Sinks:
1. Sacristy Sinks - Stainless Steel, Wall Hung <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain sinks from single source from single manufacturer.
c. Fixture:
1) Standard: ASME A112.19.3/CSA B45.4.
2) Type: [**Single**] [**Double**] bowl.
3) Material: Bowl and hinged cover, 18 gauge, Type 304, 18-8 stainless steel.
4) Nominal Size: Approximately [**20 by 23 inches**] [**21 by 42 inches**] <Insert dimensions>.
5) Cover: Hinged with lock on [**left**] [**right**] bowl.
d. Faucet: <Insert sink faucet designation from "Sink Faucets, Manually Operated" or "Sink Faucets, Automatically Operated" Paragraph>.
1) Location: On [**left**] [**right**] bowl.
e. Supply Fittings: Comply with requirements in "Sink Supply Fittings" Paragraph.
f. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Bowl:
a) Orientation: [**Left**] [**Right**].
b) Drain: Cup with stopper and NPS 1-1/2 tailpiece.
3) Opposite Bowl:
a) Drain: Grid with stopper and NPS 1-1/2 tailpiece.
4) Trap Size: NPS 1-1/2.
5) Trap Material: Comply with requirements in "Waste Fittings" Article.
6) Drain Piping: NPS 1-1/2 chrome-plated, tubular-brass direct waste without trap, separate waste piping, and wall flange.
2. Sacristy Sinks - Stainless Steel, Drop In, Two Bowl <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain sinks from single source from single manufacturer.
c. Fixture:
1) Standard: ASME A112.19.3/CSA B45.4.
2) Type: Self-rimming.
3) Material: Bowl and hinged cover, 18 gauge, Type 304, 18-8 stainless steel.
4) Nominal Size: Approximately [**17-1/2 by 37 inches**] [**18 by 29 inches**] [**22 by 28 inches**] [**22 by 33 inches**] [**22 by 42 inches**] <Insert dimensions>.
5) Cover: Hinged with lock on [**left**] [**right**] bowl.
d. Faucet: <Insert sink faucet designation from "Sink Faucets, Manually Operated" or "Sink Faucets, Automatically Operated" Paragraph>.
1) Location: On [**left**] [**right**] bowl.

e. Supply Fittings: Comply with requirements in "Sink Supply Fittings" Paragraph.
f. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Bowl:
a) Orientation: [**Left**] [**Right**].
b) Drain: Cup with stopper and NPS 1-1/2 tailpiece.
3) Opposite Bowl:
a) Drain: Grid with stopper and NPS 1-1/2 tailpiece.
4) Trap Size: NPS 1-1/2.
5) Trap Material: Comply with requirements in "Waste Fittings" Article.
6) Drain Piping: NPS 1-1/2 chrome-plated, tubular-brass direct waste without trap, separate waste piping, and wall flange.

F. Shampoo Bowls:
1. Shampoo Bowls - Enameled Cast Iron <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain bowls from single source from single manufacturer.
c. Fixture:
1) Standard: ASME A112.19.2/CSA B45.1.
2) Bowl: Shaped for head rest.
3) Nominal Size: [**19 by 19 by 10 inches**] <Insert dimensions>.
4) Color: [White] <Insert color>.
d. Faucet: Manufacturer's standard with vacuum breaker complying with ASME A112.18.3 and with hose spray head.
e. Waste Fittings: Comply with requirements in "Sink Waste Fittings" Paragraph except as follows:
1) Drain: Cup type with hair basket and NPS 1-1/2 tailpiece.
2) Trap Size: NPS 1-1/2.
f. Mounting Material: [Bracket or devices for attaching to counter] [Wall bracket].
2. Shampoo Bowls - Plastic <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain bowls from single source from single manufacturer.
c. Fixture:
1) Standard: CSA B45.5/IAPMO Z124.
2) Material: [ABS] [FRP] [PMMA] <Insert material>.
3) Bowl: Shaped for head rest.
4) Nominal Size: [**19 by 19 by 10 inches**] <Insert dimensions>.
5) Color: [White] <Insert color>.
6) Mounting Material: [Bracket or devices for attaching to counter] [Wall bracket].
d. Faucet: Manufacturer's standard with vacuum breaker complying with ASME A112.18.3 and with hose spray head.
e. Waste Fittings: Comply with requirements in "Sink Waste Fittings" Paragraph except as follows:
1) Drain: Cup type with hair basket and NPS 1-1/2 tailpiece.
2) Trap Size: NPS 1-1/2.
3. Shampoo Bowls - Solid-Surface Material <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain bowls from single source from single manufacturer.
c. Fixture:
1) Material: Molded, cast polymer.
2) Bowl: Shaped for head rest.
3) Nominal Size: [**19 by 19 by 9 inches**] [**22 by 18 by 9 inches**] <Insert dimensions>.
4) Color: [Gray granite] [Sandstone] [White granite] <Insert color>.
5) Mounting Material: [Bracket or devices for attaching to counter] [Wall bracket].
d. Faucet: Manufacturer's standard with vacuum breaker complying with ASME A112.18.3 and with hose spray head.
e. Waste Fittings: Comply with requirements in "Sink Waste Fittings" Paragraph except as follows:
1) Drain: Cup type with hair basket and NPS 1-1/2 tailpiece.
2) Trap Size: NPS 1-1/2.

G. Sink Faucets, Manually Operated:
1. Sink Faucets, Manually Operated <Insert designation>: [Single control, mixing] [Single control, nonmixing] [Two handle, mixing] [Pre-rinse] <Insert type>.
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain sink faucets from single source from single manufacturer.
c. Standards:
1) ASME A112.18.1/CSA B125.1.
2) NSF 61.
3) NSF 372.
d. Description: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
e. Body Type: [Centerset] [Widespread] [Single hole] <Insert type>.
f. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
g. Finish: [Chrome plated] [Polished chrome plate] <Insert finish>.
h. Maximum Flow Rate: [**1.0 to 1.28 gpm**] [**1.5 gpm**] <Insert value>.
i. Mounting Type: [Deck, concealed] [Deck, exposed] [Back/wall, exposed].
j. Valve Handle(s): [Lever] [Cross, four arm] [**4-inch** wrist blade] [**6-inch** wrist blade] [Not applicable] <Insert handles>.
k. Spout Type: [Rigid] [Rigid with wall brace] [Swing] [Rigid, gooseneck] [Swivel, gooseneck] <Insert type>.
l. Vacuum Breaker: [**Required**] [**Not required**] for hose outlet.
m. Spout Outlet: [Aerator] [Laminar flow] [Hose thread in accordance with ASME B1.20.7] [Plain end] [Spray] <Insert type>.
n. Pre-Rinse Unit:
1) Style: [Flexible hose] [Rigid] [Combination rigid/flexible] <Insert type>.
2) Riser: [**18-inch** rigid riser] <Insert type>.
3) Hose: [**44-inch** flexible stainless steel with heat-resistant handle] <Insert type>.
4) Spray valve: <**Insert type**>.

5) Wall bracket.

2. Sink Faucets, Manually Operated - Service Sink <**Insert designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Source Limitations: Obtain sink faucets from single source from single manufacturer.

c. Description: Wall/back mounted, brass body, with integral service stops, checks, spout with bucket/pail hook, 3/4-inch hose thread end, integral vacuum breaker, inlets 8 inches o.c., and two-handle mixing.

d. Faucet:

1) Standards:

a) ASME A112.18.1/CSA B125.1.

b) NSF 61 and NSF 372.

c) ICC A117.1.

d) ASSE 1001 (VB).

2) Finish: [Rough chrome plated] [Polished chrome plated] <Insert finish>.

3) Handles: [Lever] [**6-inch** wrist blade] [**4-inch** wrist blade] [four arms] <Insert type>.

4) Cartridges: [One-fourth turn compression] [Ceramic] <Insert type>.

5) Brace: [Adjustable top brace] [Adjustable bottom brace] <Insert type>.

e. Vacuum Breaker: [**Required**] [**Not required**] for hose outlet.

f. Spout Outlet: [Aerator] [Laminar flow] [Hose thread in accordance with ASME B1.20.7] [Plain end] [Spray] <Insert type>.

H. Sink Faucets, Automatically Operated:

1. Sink Faucets, Automatically Operated <**Insert designation**>: [**Battery powered,**] [**Hardwired,**] electronic sensor operated, [**mixing**] [**nonmixing**].

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Source Limitations: Obtain sink faucets from single source from single manufacturer.

c. Standards:

1) ASME A112.18.1/CSA B125.1.

2) UL 1951.

d. 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.

e. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.

f. Body Type: [Centerset] [Single hole] <Insert type>.

g. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.

h. Finish: [Chrome plated] [Polished chrome1 plate] <Insert finish>.

i. Maximum Flow Rate: [**0.5 gpm**] <Insert value>.

j. Mounting Type: [**Deck**] [**Back/wall**].

k. Spout Type: [Rigid] [Swing] [Rigid, gooseneck] [Swivel, gooseneck] <Insert type>.

l. Spout Outlet: [Aerator] [Laminar flow] [Spray] <Insert type>.

m. Thermostatic Mixing Valve: [Above deck,] [Below deck,] [Single temperature] [adjustable temperature manual side handle, with hot/cold water indicators], with check valves.
n. Control Module: [**Above deck,**] [**Below deck,**] water-resistant module with internal flow setting switches.
o. Drain: [Not part of faucet] <Insert type>.

I. Sink Supply Fittings:
1. NSF Standard: Comply with NSF 61 and NSF 372 for supply-fitting materials that will be in contact with potable water.
2. Standard: ASME A112.18.1/CSA B125.1.
3. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless steel wall flange.
4. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
5. Operation: [Loose key] [Wheel handle] <Insert type>.
6. Risers:
a. [**NPS 3/8**] [**NPS 1/2**].
b. [Chrome-plated, rigid-copper pipe] [Chrome-plated, soft-copper flexible tube] [ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel flexible hose].

J. Sink Waste Fittings:
1. Standard: ASME A112.18.2/CSA B125.2.
2. Drain: Grid type with NPS 1-1/2 offset and straight tailpiece.
3. Trap:
a. Size: NPS 1-1/2.
b. Material:
1) Chrome-plated, [two-piece, cast-brass trap and swivel elbow with 17-gauge brass tube to wall] [two-piece, cast-brass trap and ground-joint swivel elbow with 17-gauge brass tube to wall] [one-piece, cast-brass trap with swivel 17-gauge tubular brass wall bend] <Insert trap type>; and chrome-plated brass or steel wall flange.

K. Grout:
1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink; recommended for interior and exterior applications.
3. Design Mix: 5000 psi, 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

2.05 COMMERCIAL URINALS

A. Urinals, Stall:
1. Urinals, Stall - Washout Type <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Fixture:
1) Standards:
a) ASME A112.19.2/CSA B45.1.
b) ASME A112.19.5/CSA B45.15.
2) Material: Vitreous china.
3) Type: [Straight or sloped] <Insert type> front.
4) Seam Covers: For [**21-inch**] [**24-inch**] urinal centers.

5) Strainer: Separate; removable.
6) Water Consumption: [**0.5 gpf**] [**1.0 gpf**].
7) Spud Size and Location: NPS 3/4; [**top**] [**back**].
8) Outlet Size and Location: NPS 2; bottom for separate trap.
9) Color: [White] <Insert color>.

c. Flushometer Valve: <Insert urinal flushometer-valve designation from "Flushometer Valves" Article>.

B. Urinals, Wall Hung:

1. Urinals, Wall Hung - Back Outlet, Blowout <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Fixture:

1) Standards:
a) ASME A112.19.2/CSA B45.1.
b) ASME A112.19.5/CSA B45.15.
2) Material: Vitreous china.
3) Strainer or Trapway: [**Manufacturer's standard strainer**] [**Open trapway**] with integral trap.
4) Water Consumption: [**0.5 gpf**] [**1.0 gpf**].
5) Spud Size and Location: NPS 1-1/4; [**back**] [**top**].
6) Outlet Size and Location: NPS 2; back.
7) Color: [White] <Insert color>.

c. Flushometer Valve: <Insert urinal-flushometer-valve designation from "Flushometer Valves" Article>.

d. Waste Fitting:

1) Standard: ASME A112.18.2/CSA B125.2 for coupling.
2) Size: NPS 2.

e. Support: [**Urinal carrier, floor affixed with steel uprights**] <**Insert carrier**> with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture.

f. Urinal Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

2. Urinals, Wall Hung - Back Outlet, Siphon Jet <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Fixture:

1) Standards:
a) ASME A112.19.2/CSA B45.1.
b) ASME A112.19.5/CSA B45.15.
2) Material: Vitreous china.
3) Type: Siphon jet[with extended shields].
4) Strainer or Trapway: [Manufacturer's standard strainer] <Insert strainer> with integral trap.
5) Water Consumption: [**0.125 gpf**] [**0.25 gpf**] [**0.5 gpf**] [**1.0 gpf**].
6) Spud Size and Location: NPS 3/4; [**back**] [**top**].
7) Outlet Size and Location: NPS 2; back.
8) Color: [White] <Insert color>.

c. Flushometer Valve: <Insert urinal flushometer-valve designation from "Flushometer Valves" Article>.

d. Waste Fitting:
   1) Standard: ASME A112.18.2/CSA B125.2 for coupling.
   2) Size: NPS 2.
e. Support: [**Urinal carrier, floor affixed with steel uprights**] <**Insert carrier**> with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture.
f. Urinal Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

3. Urinals, Wall Hung - Back Outlet, Washout <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Fixture:
   1) Standards:
      a) ASME A112.19.2/CSA B45.1.
      b) ASME A112.19.5/CSA B45.15.
   2) Material: Vitreous china.
   3) Type: Washout with extended shields.
   4) Strainer or Trapway: [Manufacturer's standard strainer] <Insert strainer> with integral trap.
   5) Water Consumption: [**0.125 gpf**] [**0.25 gpf**] [**0.5 gpf**] [**1.0 gpf**].
   6) Spud Size and Location: NPS 3/4, [**back**] [**top**].
   7) Outlet Size and Location: NPS 2, back.
   8) Color: [White] <Insert color>.
c. Flushometer Valve: <Insert urinal flushometer-valve designation from "Flushometer Valves" Article>.
d. Waste Fitting:
   1) Standard: ASME A112.18.2/CSA B125.2 for coupling.
   2) Size: NPS 2.
e. Support: [**Urinal carrier, floor affixed with steel uprights**] <**Insert carrier**> with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture.
f. Urinal Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

4. Urinals, Wall Hung - Bottom Outlet, Washout <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Fixture:
   1) Standards:
      a) ASME A112.19.2/CSA B45.1.
      b) ASME A112.19.5/CSA B45.15.
   2) Material: Vitreous china.
   3) Drain: Separate removable chrome-plated dome strainer with chrome-plated, NPS 1-1/2 tailpiece.
   4) Strainer or Trapway: Manufacturer's standard strainer and NPS 1-1/2 tailpiece.
   5) Inlet Spud Size and Location: NPS 3/4; top.
   6) Outlet Size and Location: NPS 1-1/2; bottom.
   7) Color: [White] <Insert color>.
   8) Water Consumption: [**0.125 gpf**] [**0.25 gpf**] [**0.5 gpf**] [**1.0 gpf**].

c. Flushometer Valve: <Insert urinal flushometer-valve designation from "Flushometer Valves" Article>.
d. Waste Fitting:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Trap:
a) Size: NPS 1-1/2.
b) Material, Chrome Plated: [Two-piece, cast-brass trap and swivel elbow with **0.032-inch-**thick brass tube to wall] [two-piece, cast-brass trap and ground-joint swivel elbow with **0.032-inch-**thick brass tube to wall] [one-piece, cast-brass trap with swivel **0.029-inch-**thick tubular brass wall bend] <Insert trap type>; and chrome-plated brass or steel wall flange.
c) Material, Stainless Steel: Two-piece trap and swivel elbow with 0.012-inch-thick, stainless steel tube to wall; and stainless steel wall flange.
e. Support: [Urinal carrier, floor affixed with steel uprights] <Insert carrier> with hanger and bearing plates.
f. Urinal Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

5. Urinals, Wall Hung - Back Outlet, Washdown <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Fixture:
1) Standards:
a) ASME A112.19.2/CSA B45.1.
b) ASME A112.19.5/CSA B45.15.
2) Material: Vitreous china.
3) Type: Washdown with extended shields.
4) Strainer or Trapway: [Manufacturer's standard strainer] <Insert strainer> with integral trap.
5) Water Consumption: [**0.125 gpf**] [**0.25 gpf**] [**0.5 gpf**] [**1.0 gpf**].
6) Spud Size and Location: NPS 3/4, [**back**] [**top**].
7) Outlet Size and Location: NPS 2, back.
8) Color: [White] <Insert color>.
c. Flushometer Valve: <Insert urinal flushometer-valve designation from "Flushometer Valves" Article>.
d. Waste Fitting:
1) Standard: ASME A112.18.2/CSA B125.2 for coupling.
2) Size: NPS 2.
e. Support: [**Urinal carrier, floor affixed with steel uprights**] <**Insert carrier**> with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture.
f. Urinal Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

C. Urinals, Waterless:
1. Urinals, Waterless - Vitreous China, Wall Hung, Back Outlet <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Fixture:

1) Standard: ASME A112.19.2/CSA B45.1, except without water supply.
2) Designed for liquid-trap-seal operation.
3) Trap-Seal Method: Proprietary cartridge with liquid seal.
4) Outlet Size and Location: [**NPS 2**] <**Insert pipe size**> flange; back.
5) Trap-Sealing Liquid: Proprietary.
6) Color: [White] <Insert color>.

c. Waste Fitting:
1) Standard: ASME A112.18.2/CSA B125.2 for transition coupling, trap, and waste pipe.
2) Size: [**NPS 2**] <Insert pipe size>.

d. Support: [**Urinal carrier, floor affixed with steel uprights**] <**Insert carrier**> with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture.

e. Urinal Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

2. Urinals, Waterless - Plastic, Wall Hung, Back Outlet <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Fixture:
1) Standard: CSA B45.5/IAPMO Z124, except without water supply.
2) Designed for liquid-trap-seal operation.
3) Material: [FRP] <Insert material>.
4) Trap-Seal Method: Proprietary cartridge or trap system.
5) Outlet Size and Location: NPS 2; back. Include transition coupling.
6) Trap-Sealing Liquid: Proprietary.
7) Color: [White] <Insert color>.

c. Waste Fitting:
1) Standard: ASME A112.18.2/CSA B125.2 for transition coupling, trap, and waste pipe.
2) Size: [**NPS 2**] <Insert pipe size>.

d. Support: [Metal plate in wall] [Wood blocking in wall] [Urinal carrier, floor affixed with steel uprights] <Insert carrier> [with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture].

e. Urinal Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

2.06 COMMERCIAL WATER CLOSETS

A. Water Closets, Floor Mounted:

1. Water Closets, Floor Mounted - Bottom Outlet, Top Spud <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Source Limitations: Obtain water closets from single source from single manufacturer.

c. Standard: ASME A112.19.2/CSA B45.1.

d. Bowl:
1) Material: Vitreous china.
2) Type: Siphon jet.
3) Style: Flushometer valve.
4) Height: [Standard] [Accessible in accordance with ICC A117.1].

5) Rim Contour: Elongated.
6) Water Consumption: [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] [Dual flush **1.1 gal. /1.28 gal.**] [Dual flush **1.1 gal. /1.6 gal.**] per flush.
7) Spud Size and Location: NPS 1-1/2; top.
8) Color: [White] <Insert color>.

e. Flushometer Valve: <Insert flushometer-valve designation>.
f. Toilet Seat: <Insert toilet-seat designation>.

2. Water Closets, Floor Mounted - Bottom Outlet, Back Spud **<Insert drawing designation>**:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain water closets from single source from single manufacturer.
c. Standard: ASME A112.19.2/CSA B45.1
d. Bowl:
1) Material: Vitreous china.
2) Type: Siphon jet.
3) Style: Flushometer valve.
4) Height: [Standard] [Accessible in accordance with ICC A117.1].
5) Rim Contour: Elongated.
6) Water Consumption: [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] [Dual flush **1.1gal. /1.28 gal.**] [Dual flush **1.1 gal. /1.6 gal.**] per flush.
7) Spud Size and Location: NPS 1-1/2; back.
8) Color: [White] <Insert color>.

e. Flushometer Valve: <Insert flushometer-valve designation>.
f. Toilet Seat: <Insert toilet-seat designation>.

3. Water Closets, Floor Mounted - Bottom Outlet, Close-Coupled Flushometer Tank **<Insert drawing designation>**:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain water closets from single source from single manufacturer.
c. Standard: ASME A112.19.2/CSA B45.1.
d. Bowl:
1) Material: Vitreous china.
2) Type: Siphon jet.
3) Style: Flushometer tank, [**gravity**] [**pressure assisted**].
4) Height: [Standard] [Accessible in accordance with ICC A117.1].
5) Rim Contour: Elongated.
6) Water Consumption: [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] [Dual flush **1.1 gal. /1.6 gal.**] per flush.
7) Color: [White] <Insert color>.

e. Toilet Seat: <Insert toilet-seat designation>.

4. Water Closets, Floor Mounted - Bottom Outlet, Juvenile **<Insert drawing designation>**:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain water closets from single source from single manufacturer.

c. Standard: ASME A112.19.2/CSA B45.1.
d. Bowl:
1) Material: Vitreous china.
2) Type: Siphon jet.
3) Style: Flushometer valve.
4) Height: [**10 inches**] [**14 inches**] <Insert height>.
5) Rim Contour: Elongated.
6) Water Consumption: [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] per flush.
7) Spud Size and Location: NPS 1-1/2; top.
8) Color: [White] <Insert color>.
e. Flushometer Valve: <Insert flushometer-valve designation>.
f. Toilet Seat: <Insert toilet-seat designation>.

5. Water Closets, Floor Mounted - Back Outlet, Top Spud <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain water closets from single source from single manufacturer.
c. Standard: ASME A112.19.2/CSA B45.1
d. Bowl:
1) Material: Vitreous china.
2) Type: Siphon jet.
3) Style: Flushometer valve.
4) Height: [Standard] [Accessible in accordance with ICC A117.1].
5) Rim Contour: Elongated.
6) Water Consumption: [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] [Dual flush **1.1 gal.** /**1.28 gal.**] [Dual flush **1.1 gal.** /**1.6 gal.**] per flush.
7) Spud Size and Location: NPS 1-1/2; top.
8) Color: [White] <Insert color>.
e. Flushometer Valve: <Insert flushometer-valve designation>.
f. Toilet Seat: <Insert toilet-seat designation>.
g. Support: [Water-closet carrier, floor affixed] <Insert carrier>.

6. Water Closets, Floor Mounted - Back Outlet, Back Spud <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain water closets from single source from single manufacturer.
c. Standard: ASME A112.19.2/CSA B45.1.
d. Bowl:
1) Material: Vitreous china.
2) Type: Siphon jet.
3) Style: Flushometer valve.
4) Height: [Standard] [Accessible in accordance with ICC A117.1].
5) Rim Contour: Elongated.
6) Water Consumption: [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] [Dual flush **1.1 gal.** /**1.28 gal.**] [Dual flush **1.1 gal.** /**1.6 gal.**] per flush.
7) Spud Size and Location: NPS 1-1/2; back.
8) Color: [White] <Insert color>.

e. Flushometer Valve: <Insert flushometer-valve designation>.
f. Toilet Seat: <Insert toilet-seat designation>.
g. Support: [Water-closet carrier, floor affixed] <Insert carrier>.

7. Water Closets, Floor Mounted - Back Outlet, Close-Coupled Flushometer Tank <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain water closets from single source from single manufacturer.
c. Standard: ASME A112.19.2/CSA B45.1.
d. Bowl:
1) Material: Vitreous china.
2) Type: Siphon jet.
3) Style: Flushometer tank, [**gravity**] [**pressure assisted**].
4) Height: [Standard] [Accessible in accordance with ICC A117.1].
5) Rim Contour: Elongated.
6) Water Consumption: [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] per flush.
7) Color: [White] <Insert color>.
e. Toilet Seat: <Insert toilet-seat designation>.
f. Support: [Water-closet carrier, floor affixed] <Insert carrier>.

B. Water Closets, Wall Mounted:
1. Water Closets, Wall Mounted - Top Spud <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain water closets from single source from single manufacturer.
c. Standard: ASME A112.19.2/CSA B45.1.
d. Bowl:
1) Material: Vitreous china.
2) Type: Siphon jet.
3) Style: Flushometer valve.
4) Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].
5) Rim Contour: Elongated.
6) Water Consumption: [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] [Dual flush **1.1 gal.** /**1.28 gal.**] [Dual flush **1.1 gal.** /**1.6 gal.**] per flush.
7) Spud Size and Location: NPS 1-1/2; top.
8) Color: [White] <Insert color>.
e. Flushometer Valve: <Insert flushometer-valve designation>.
f. Toilet Seat: <Insert toilet-seat designation>.
g. Support: [Water-closet carrier, floor affixed] <Insert carrier>.

2. Water Closets, Wall Mounted - Back Spud <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain water closets from single source from single manufacturer.
c. Standard: ASME A112.19.2/CSA B45.1.
d. Bowl:
1) Material: Vitreous china.

2) Type: Siphon jet.
3) Style: Flushometer valve.
4) Mounting Height: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].
5) Rim Contour: Elongated.
6) Water Consumption: [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] [Dual flush **1.1 gal.** /**1.28 gal.**] [Dual flush **1.1 gal.** /**1.6 gal.**] per flush.
7) Spud Size and Location: NPS 1-1/2; back.
8) Color: [White] <Insert color>.

e. Flushometer Valve: <Insert flushometer-valve designation>.
f. Toilet Seat: <Insert toilet-seat designation>.
g. Support: [Water-closet carrier, floor affixed] <Insert carrier>.

3. Water Closets, Wall Mounted - Back Outlet, Close-Coupled Flushometer Tank <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain water closets from single source from single manufacturer.
c. Standard: ASME A112.19.2/CSA B45.1.
d. Bowl:
1) Material: Vitreous china.
2) Type: Siphon jet.
3) Style: Flushometer tank, [**gravity**] [**pressure assisted**].
4) Height: [Standard] [Accessible in accordance with ICC A117.1].
5) Rim Contour: Elongated.
6) Water Consumption: [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] per flush.
7) Color: [White] <Insert color>.
e. Toilet Seat: <Insert toilet-seat designation>.
f. Support: [Water-closet carrier, floor affixed] <Insert carrier>.

2.07 COMMERCIAL WASH FOUNTAINS

A. Wash Fountains, Circular Receptor:

1. Wash Fountains, Circular Receptor - Solid Surface <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain wash fountains from single source from single manufacturer.
c. Standards:
1) IAPMO IGC 156.
2) CSA B45.5/IAPMO Z124.
3) ASME A112.18.1/CSA B125.1.
d. Receptor:
1) Nominal Diameter: [**36 inches**] [or] [**39 inches**] [**54 inches**].
2) Height to Rim: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].
3) Color or Finish: [Not applicable] <Insert if required>.
4) Drain: Grid with [**NPS 2**] <**Insert pipe size**> tailpiece.
e. Spray Head:
1) Material: Stainless steel.
2) Number of User Stations: <**Insert number**>.

3) Control: [Collective,] [Individual,] [foot-control] [pneumatic push-button] [infrared sensor] [low-voltage, mechanical metering] actuation with [pressure-balancing] [thermostatic] mixing valve, and having check stops.

f. Soap Dispensers: [**Not required**] [**Bracket only**] [**Foam**] [**Powdered**] [**Liquid**] <**Insert type**>, for each user station.

g. Pedestal: [Manufacturer's standard] [Painted or coated steel] [Stainless steel] with access panel.

h. Supply Fittings:
1) Piping: [**NPS 3/4**] [**NPS 1**] copper tubing.
2) Valves: Shutoff valve on each supply.
3) Supply Piping: From [**bottom**] [**top**].

i. Waste Fittings:
1) Trap and Drain Piping: [**NPS 2**].
2) Vent Piping: [Not required] [**NPS 1-1/2** to ceiling].

j. Shroud: [Not required] [Stainless steel of size to cover supply and vent piping].

k. Mounting: Manufacturer's standard floor bracket.

2. Wash Fountains, Circular Receptor - Stainless Steel <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Source Limitations: Obtain wash fountains from single source from single manufacturer.

c. Standards:
1) IAPMO IGC 156.
2) ASME A112.18.1/CSA B125.1
3) ASME A112.19.3/CSA B45.4.

d. Receptor:
1) Nominal Diameter: [**36 inches**] [or] [**39 inches**] [**42 inches**] [**54 inches**].
2) Height to Rim: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].
3) Color or Finish: [Not applicable] <Insert if required>.
4) Drain: Grid with [**NPS 2**] <**Insert pipe size**> tailpiece.

e. Spray Head:
1) Material: Stainless steel.
2) Number of User Stations: <**Insert number**>.
3) Control: [Collective,] [Individual,] [foot-control] [pneumatic push-button] [infrared sensor] [low-voltage, mechanical metering] actuation with [pressure-balancing] [thermostatic] mixing valve, and having check stops.

f. Soap Dispensers: [**Not required**] [**Bracket only**] [**Foam**] [**Powdered**] [**Liquid**] <**Insert type**> for each user station.

g. Pedestal: Stainless steel with access panel.

h. Supply Fittings:
1) Piping: [**NPS 3/4**] [**NPS 1**] copper tubing.
2) Valves: Shutoff valve on each supply.
3) Supply Piping: From [**bottom**] [**top**].

i. Waste Fittings:
1) Trap and Drain Piping: [**NPS 2**].
2) Vent Piping: [Not required] [**NPS 1-1/2** to ceiling].

j. Shroud: [Not required] [Stainless steel of size to cover supply and vent piping].

k. Mounting: Manufacturer's standard floor bracket.

B. Wash Fountains, Semicircular Receptor:

1. Wash Fountains, Semicircular Receptor - Solid Surface, Floor or Wall Mounted <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Source Limitations: Obtain wash fountains from single source from single manufacturer.

c. Standards:

1) IAPMO IGC 156.

2) ASME A112.18.1/CSA B125.1.

3) CSA B45.5/IAPMO Z124.

d. Receptor:

1) Nominal Diameter: [**36 inches**] [or] [**39 inches**] [**46 inches**] [**54 inches**].

2) Height to Rim: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].

3) Color or Finish: [Not applicable] <Insert if required>.

4) Drain: Grid with [**NPS 1-1/2**] [**NPS 2**] tailpiece.

e. Spray Head:

1) Material: Stainless steel or integral part of receptor back.

2) Number of User Stations: <**Insert number**>.

3) Control: [Collective,] [Individual,] [foot-control] [pneumatic push-button] [infrared sensor] [low-voltage, mechanical metering] <Insert type> actuation with [pressure-balancing] [thermostatic] mixing valve, and having check stops.

f. Soap Dispensers: [**Not required**] [**Bracket only**] [**Foam**] [**Powdered**] [**Liquid**] <**Insert type**>, for each user station.

g. Supply Fittings:

1) Piping: [**NPS 1/2**] [**NPS 3/4**] copper tubing.

2) Valves: Shutoff valve on each supply.

3) Supply Piping: From [**bottom**] [**top**] [**wall**].

h. Waste Fittings:

1) Trap and Drain Piping: [**NPS 1-1/2**] [**NPS 2**].

2) Vent Piping: [Not required] [**NPS 1-1/2** to ceiling].

i. Shroud: [Not required] [Stainless steel of size to cover supply and vent piping].

j. Wall Mounting: [Manufacturer's wall-mounting bracket] [and/or] [wash fountain carrier] <Insert type>.

k. Floor Mounting: Manufacturer's floor bracket and wall bracket attached to [**reinforcement in**] [**concrete or block**] wall.

2. Wash Fountains, Semicircular Receptor - Stainless Steel, Floor or Wall Mounted <**Insert drawing designation**>:

a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Source Limitations: Obtain wash fountains from single source from single manufacturer.

c. Standards:

1) IAPMO IGC 156.

2) ASME A112.18.1/CSA B125.1.

3) ASME A112.19.3/CSA B45.4.

d. Receptor:
   1) Nominal Diameter: [**36 inches**] [or] [**39 inches**] [**42 inches**] [**54 inches**].
   2) Height to Rim: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].
   3) Color or Finish: [Not applicable] <Insert if required>.
   4) Drain: Grid with [**NPS 1-1/2**] [**NPS 2**] tailpiece.
e. Spray Head:
   1) Material: Stainless steel or integral part of receptor back.
   2) Number of User Stations: <**Insert number**>.
   3) Control: [Collective,] [Individual,] [foot-control] [pneumatic push-button] [infrared sensor] [low-voltage, mechanical metering] <Insert type> actuation with [pressure-balancing] [thermostatic] mixing valve, and having check stops.
f. Soap Dispensers: [**Not required**] [**Bracket only**] [**Foam**] [**Powdered**] [**Liquid**] <**Insert type**>, for each user station.
g. Supply Fittings:
   1) Piping: [**NPS 1/2**] [**NPS 3/4**] copper tubing.
   2) Valves: Shutoff valve on each supply.
   3) Supply Piping: From [**bottom**] [**top**] [**wall**].
h. Waste Fittings:
   1) Trap and Drain Piping: [**NPS 1-1/2**] [**NPS 2**].
   2) Vent Piping: [Not required] [**NPS 1-1/2** to ceiling].
i. Shroud: [Not required] [Stainless steel of size to cover supply and vent piping].
j. Wall Mounting: [Manufacturer's wall-mounting bracket] [and/or] [wash fountain carrier] <Insert type>.
k. Floor Mounting: Manufacturer's floor bracket and wall bracket attached to [**reinforcement in**] [**concrete or block**] wall.

C. Wash Fountains, Corner Receptor:
1. Wash Fountains, Corner Receptor - Precast Terrazzo <**Insert drawing designation**>:
   a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
   b. Source Limitations: Obtain wash fountains from single source from single manufacturer.
   c. Standards:
      1) IAPMO IGC 156.
      2) ASME A112.18.1/CSA B125.1.
      3) CSA B45.8/IAPMO Z403.
   d. Receptor:
      1) Nominal Side Width: [**27 inches**] [**37 inches**].
      2) Height to Rim: [**Standard**] [**Juvenile**].
      3) Color or Finish: [Not applicable] <Insert if required>.
      4) Drain: Grid with NPS 1-1/2 tailpiece.
   e. Spray Head:
      1) Material: Stainless steel or integral part of receptor back.
      2) Number of User Stations: <**Insert number**>.
      3) Control: [Foot-control] [Pneumatic push-button] [Infrared sensor] [Low-voltage, mechanical metering] <Insert type> actuation with [pressure-balancing] [thermostatic] mixing valve, and having check stops.

f. Soap Dispensers: [**Not required**] [**Bracket only**] [**Foam**] [**Powdered**] [**Liquid**] <**Insert type**>, for each user station.
g. Supply Fittings:
1) Piping: [**NPS 1/2**] [**NPS 3/4**] copper tubing.
2) Valves: Shutoff valve on each supply.
3) Supply Piping: From wall.
h. Waste Fittings:
1) Trap and Drain Piping: NPS 1-1/2.
i. Mounting: Manufacturer's standard floor and wall bracket.

2. Wash Fountains, Corner Receptor - Solid Surface, Floor or Wall Mounted <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain wash fountains from single source from single manufacturer.
c. Standards:
1) IAPMO IGC 156.
2) ASME A112.18.1/CSA B125.1.
3) CSA B45.5/IAPMO Z124.
d. Receptor:
1) Nominal Side Width: [**27 inches**] [**37 inches**].
2) Height to Rim: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].
3) Color or Finish: [Not applicable] <Insert if required>.
4) Drain: Grid with NPS 1-1/2 tailpiece.
e. Spray Head:
1) Material: Stainless steel or integral part of receptor back.
2) Number of User Stations: <**Insert number**>.
3) Control: [Collective,] [Individual,] [foot-control] [pneumatic push-button] [infrared sensor] [low-voltage, mechanical metering] <Insert type> actuation with [pressure-balancing] [thermostatic] mixing valve, and having check stops.
f. Soap Dispensers: [**Not required**] [**Bracket only**] [**Foam**] [**Powdered**] [**Liquid**] <**Insert type**>, for each user station.
g. Supply Fittings:
1) Piping: [**NPS 1/2**] [**NPS 3/4**] copper tubing.
2) Valves: Shutoff valve on each supply.
3) Supply Piping: From wall.
h. Waste Fittings:
1) Trap and Drain Piping: NPS 1-1/2.
i. Wall Mounting: [Manufacturer's wall-mounting bracket] [and/or] [wash fountain carrier] <Insert type>.
j. Floor Mounting: Manufacturer's floor bracket and wall bracket attached to [**reinforcement in**] [**concrete or block**] wall.

3. Wash Fountains, Corner Receptor - Stainless Steel, Floor or Wall Mounted <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

b. Source Limitations: Obtain wash fountains from single source from single manufacturer.
c. Standards:
1) IAPMO IGC 156.
2) ASME A112.18.1/CSA B125.1
3) ASME A112.19.3/CSA 45.4.
d. Receptor:
1) Nominal Side Width: [**37 inches**] [**38 inches**] [**44 inches**].
2) Height to Rim: [Standard] [Juvenile] [Accessible in accordance with ICC A117.1].
3) Color or Finish: [Not applicable] <Insert if required>.
4) Drain: Grid with NPS 1-1/2 tailpiece.
e. Spray Head:
1) Material: Stainless steel or integral part of receptor back.
2) Number of User Stations: <**Insert number**>.
3) Control: [Collective,] [Individual,] [foot-control] [pneumatic push-button] [infrared sensor] [low-voltage, mechanical metering] <Insert type> actuation with [pressure-balancing] [thermostatic] mixing valve, and having check stops.
f. Soap Dispensers: [**Not required**] [**Bracket only**] [**Foam**] [**Powdered**] [**Liquid**] <**Insert type**>, for each user station.
g. Supply Fittings:
1) Piping: [**NPS 1/2**] [**NPS 3/4**] copper tubing.
2) Valves: Shutoff valve on each supply.
3) Supply Piping: From wall.
h. Waste Fittings:
1) Trap and Drain Piping: NPS 1-1/2.
i. Wall Mounting: [Manufacturer's wall-mounting bracket] [and/or] [wash fountain carrier] <Insert type>.
j. Floor Mounting: Manufacturer's floor bracket and wall bracket attached to [**reinforcement in**] [**concrete or block**] wall.

D. Wash Fountains, Linear Receptor:
1. Wash Fountains, Linear Receptor - Solid Surface <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain wash fountains from single source from single manufacturer.
c. Standards:
1) ASME A112.18.1/CSA B125.1.
2) CSA B45.5/IAPMO Z124.
3) NSF 61.
4) NSF 372.
5) UPC, IPC, and UL GREENGUARD certified.
d. 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.
e. Bowl(s) and Counter:
1) Material: Solid-surface or natural quartz surface.

2) Height to Rim: [Standard] [Accessible in accordance with ICC A117.1] <Insert height>.
3) Color or Finish: [Not applicable] <Insert if required>.
4) Number of Bowls or User Stations: [**One**] [**Two**] [**Three**] [**Four**] <**Insert number**>.
5) Bowl Shape: [Trough] [Edge] [Oval] [Round] [Square] [Rectangular] <Insert shape>.
6) Drain: Grid with NPS 1-1/2 tailpiece, each bowl.

f. Apron: [Not required] [Required, with access panel].
g. Faucets:
1) Type: Manufacturer's standard, chrome-plated solid brass, each bowl/station.
2) Control: [Manual, push-button] [Hardwired, control-voltage, sensor-actuated] [Battery-powered, sensor-actuated] <Insert type> actuation with [pressure-balancing] [thermostatic] mixing valve, and having check stops for each bowl or user station.
h. Soap Dispensers: [Not required] [Bracket only] [Manual] [Hardwired, control-voltage, sensor-actuated] [Battery-powered, sensor-actuated] [, liquid] [, foam] [, powdered] <Insert type> dispenser for each user station.
i. Mounting: [Manufacturer's wall-mounting bracket] [and/or] [commercial floor-mounted carrier] <Insert type>.
j. Supply Fittings:
1) Piping: NPS 1/2 copper tubing, each bowl.
2) Valves: Shutoff valve on each supply.
3) Supply Piping: From wall.
k. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Trap and Drain Piping: NPS 1-1/2, each bowl.

2. Wash Fountains, Linear Receptor - Stainless Steel <**Insert drawing designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain wash fountains from single source from single manufacturer.
c. Standards:
1) ASME A112.18.1/CSA B125.1.
2) ASME A112.19.3/CSA B45.4.
3) NSF 61.
4) NSF 372.
5) UPC, IPC, and UL GREENGUARD certified.
d. 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.
e. Bowl(s) and Counter:
1) Material: Stainless steel.
2) Height to Rim: [Standard] [Accessible in accordance with ICC A117.1] <Insert height>.
3) Color or Finish: [Not applicable] <Insert if required>.
4) Number of Bowls or User Stations: [**One**] [**Two**] [**Three**] [**Four**] <**Insert number**>.

5) Bowl Shape: [Trough] [Oval] [Round] <Insert shape>.
6) Drain: Grid with NPS 1-1/2 tailpiece, each bowl.

f. Apron: [Not required] [Required, with access panel].
g. Faucets:
1) Type: Manufacturer's standard, chrome-plated solid brass, each bowl/station.
2) Control: [Manual, push-button] [Hardwired, control-voltage, sensor-actuated] [Battery-powered, sensor-actuated] <Insert type> actuation with [pressure-balancing] [thermostatic] mixing valve, and having check stops for each bowl or user station.
h. Soap Dispensers: [Not required] [Bracket only] [Manual] [Hardwired, control-voltage, sensor-actuated] [Battery-powered, sensor-actuated] [, liquid] [, foam] [, powered] <Insert type> dispenser for each user station.
i. Mounting: [Manufacturer's wall-mounting bracket] [and/or] [commercial floor-mounted carrier] <Insert type>.
j. Supply Fittings:
1) Piping: NPS 1/2 copper tubing, each bowl.
2) Valves: Shutoff valve on each supply.
3) Supply Piping: From wall.
k. Waste Fittings:
1) Standard: ASME A112.18.2/CSA B125.2.
2) Trap and Drain Piping: NPS 1-1/2, each bowl.

2.08 FLUSHOMETER VALVES

A. Flushometer Valves, Manually Operated:
1. Flushometer Valves, Manually Operated - Diaphragm, Lever Handle <**Insert designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
c. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
d. Minimum Pressure Rating: 125 psig.
e. Features: Include integral check stop and backflow-prevention device.
f. Material: Brass body with corrosion-resistant components.
g. Style: Exposed.
h. Flushometer-Valve Finish: Chrome-plated.
i. Handle Finish: [Chrome plated] [Antimicrobial].
j. Consumption: [**0.125 gal.**] [**0.5 gal.**] [**1.0 gal.**] [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] [Dual flush **1.1 gal.** /**1.28 gal.**] [Dual flush **1.1 gal.** /**1.6 gal.**] <Insert value> per flush.
k. Minimum Inlet: [**NPS 3/4**] [**NPS 1**].
l. Minimum Outlet: [**NPS 3/4**] [**NPS 1-1/4**].
2. Flushometer Valves, Manually Operated - Piston, Lever Handle <**Insert designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
c. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
d. Minimum Pressure Rating: 125 psig.

e. Features: Include integral check stop and backflow-prevention device.
f. Material: Brass body with corrosion-resistant components.
g. Style: Exposed.
h. Flushometer-Valve Finish: Chrome-plated.
i. Handle Finish: [Chrome-plated] [Antimicrobial].
j. Consumption: [**0.125 gal.**] [**0.5 gal.**] [**1.0 gal.**] [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] <Insert value> per flush.
k. Minimum Inlet: [**NPS 3/4**] [**NPS 1**].
l. Minimum Outlet: [**NPS 3/4**] [**NPS 1-1/4**].

B. Flushometer Valves, Sensor Operated:

1. Flushometer Valves, Sensor Operated - Diaphragm <**Insert designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
c. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
d. Minimum Pressure Rating: 125 psig.
e. Features: Include integral check stop and backflow-prevention device.
f. Material: Brass body with corrosion-resistant components.
g. Style: [Exposed] [Concealed].
h. Exposed Flushometer-Valve Finish: Chrome-plated.
i. Panel Finish: Chrome-plated or stainless steel.
j. Actuator: Side or top mounted; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
k. Trip Mechanism: [**Battery-powered**] [**Hardwired, control-voltage**] electronic sensor; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
l. Consumption: [**0.125 gal.**] [**0.5 gal.**] [**1.0 gal.**] [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] <Insert value> per flush.
m. Minimum Inlet: [**NPS 3/4**] [**NPS 1**].
n. Minimum Outlet: [**NPS 3/4**] [**NPS 1-1/4**].

2. Flushometer Valves, Sensor Operated - Piston, Hardwired <**Insert designation**>:
a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
b. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
c. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
d. Minimum Pressure Rating: 125 psig.
e. Features: Include integral check stop and backflow-prevention device.
f. Material: Brass body with corrosion-resistant components.
g. Style: [Exposed] [Concealed].
h. Exposed Flushometer-Valve Finish: Chrome-plated.
i. Panel Finish: Chrome-plated or stainless steel.
j. Trip Mechanism: Hardwired, control-voltage electronic sensor; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
k. Consumption: [**0.125 gal.**] [**0.5 gal.**] [**1.0 gal.**] [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] [Dual flush **1.1 gal.** /**1.28 gal.**] [Dual flush **1.1 gal.** /**1.6 gal.**] <Insert value> per flush.
l. Minimum Inlet: [**NPS 3/4**] [**NPS 1**].

m. Minimum Outlet: [**NPS 3/4**] [**NPS 1-1/4**].

C. Flushometer Valves, Sensor Operated - Piston, Battery Powered <**Insert designation**>:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
3. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
4. Minimum Pressure Rating: 125 psig.
5. Features: Include integral check stop and backflow-prevention device.
6. Material: Brass body with corrosion-resistant components.
7. Style: [Exposed] [Concealed].
8. Exposed Flushometer-Valve Finish: Chrome plated.
9. Panel Finish: Chrome-plated or stainless steel.
10. Trip Mechanism: Battery-powered electronic sensor; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
11. Consumption: [**0.125 gal.**] [**0.5 gal.**] [**1.0 gal.**] [**1.1 gal.**] [**1.28 gal.**] [**1.6 gal.**] [Dual flush **1.1 gal.** /**1.28 gal.**] [Dual flush **1.1 gal.** /**1.6 gal.**] <Insert value> per flush.
12. Minimum Inlet: [**NPS 3/4**] [**NPS 1**].
13. Minimum Outlet: [**NPS 3/4**] [**NPS 1-1/4**].

2.09 TOILET SEATS

A. Toilet Seats <Insert drawing designation>:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain toilet seat from single source from single manufacturer.
3. Standard: IAPMO/ANSI Z124.5.
4. Material: Plastic.
5. Type: Commercial (Heavy duty).
6. Shape: [Elongated rim, open front] [Elongated rim, closed front] <Insert shape>.
7. Hinge: [Check] [Self-sustaining, check].
8. Hinge Material: Noncorroding metal.
9. Seat Cover: [Required] [Not required].
10. Color: [White] <Insert color>.
11. Surface Treatment: [**Antimicrobial**] [**Not required**].

2.10 FIXTURE CARRIERS

A. Fixture Carriers - Lavatory <**Insert drawing designation**>:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain lavatory carriers from single source from single manufacturer.
3. Standards:
   a. ASME A112.6.1M.
   b. ASME A112.6.2.

B. Fixture Carriers - Sink <**Insert drawing designation**>:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain sink carriers from single source from single manufacturer.
3. Standards:
   a. ASME A112.6.1M.
   b. ASME A112.6.2.

C. Fixture Carriers - Urinal <**Insert drawing designation**>:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Source Limitations: Obtain urinal carriers from single source from single manufacturer.
3. Standard: ASME A112.6.1M.
4. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings, gaskets, and feet; bolts and hardware matching fixture.[**Include additional extension coupling, faceplate, and feet for installation in wide pipe space.**]

D. Fixture Carriers - Water Closet <**Insert drawing designation**>:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain water closet carriers from single source from single manufacturer.
3. Standard: ASME A112.6.1M.
4. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings, gaskets, and feet; bolts and hardware matching fixture.[**Include additional extension coupling, faceplate, and feet for installation in wide pipe space.**]

E. Fixture Carriers - Wash Fountain <**Insert drawing designation**>:
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Source Limitations: Obtain wash fountain carriers from single source from single manufacturer.
3. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine roughing-in of water-supply piping and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.
B. Examine walls and floors for suitable conditions where plumbing fixtures will be installed.
C. Examine counters for suitable conditions where lavatories and sinks will be installed.
D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF COMMERCIAL PLUMBING FIXTURES

A. Lavatory Installation:
1. Install lavatories level and plumb in accordance with roughing-in drawings.
2. Install supports, affixed to building substrate, for wall-mounted lavatories.
3. Install accessible, wall-mounted lavatories at mounting height in accordance with ICC A117.1.
4. Install water-supply piping with stop on each supply to each lavatory faucet. Install stops in locations that are accessible for ease of operation.
5. Install trap and waste piping on each drain outlet of each lavatory to be connected to sanitary drainage system.
6. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
7. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
8. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

B. Shower Installation:

1. Assemble shower components in accordance with manufacturers' written instructions.
2. Install showers level and plumb in accordance with roughing-in drawings.
3. Install ball[**or gate**] valves in water-supply piping to the shower if supply stops are specified with the shower valve. Comply with ball[**or gate**] valve requirements specified in Section 220523 "General Duty Valves for Plumbing Piping." Install valves in locations that are accessible for ease of operation.
4. Install shower flow-control fittings with specified maximum flow rates in shower arms.
5. Set [**shower receptors**] [**and**] [**shower basins**] in leveling bed of cement grout.
6. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
7. Seal joints between showers, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

C. Sink Installation:
1. Install sinks level and plumb in accordance with roughing-in drawings.
2. Install supports, affixed to building substrate, for wall-mounted sinks.
3. Install accessible, wall-mounted sinks at mounting height in accordance with ICC A117.1.
4. Set floor-mounted sinks in leveling bed of cement grout.
5. Install water-supply piping with stop on each supply to each sink faucet.
   a. Exception: Use ball or gate valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 220523 "General Duty Valves for Plumbing Piping."
   b. Install stops/valves in locations that are accessible for ease of operation.
6. Install trap and waste piping on each drain outlet of each sink to be connected to sanitary drainage system.
7. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
8. Seal joints between sinks, counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
9. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

D. Urinal Installation:
1. Install urinals level and plumb in accordance with roughing-in drawings.
2. Install wall-hung, back-outlet urinals onto waste-fitting seals and attached to supports.
3. Install wall-hung, bottom-outlet urinals with tubular waste piping attached to supports.
4. Install accessible, wall-mounted urinals at mounting height in accordance with ICC A117.1.
5. Install trap-seal liquid in waterless urinals.

6. Install supports, affixed to building substrate, for wall-hung urinals.
7. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
8. Use carriers without waste fitting for urinals with tubular waste piping.
9. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.
10. Measure support height installation from finished floor, not structural floor.
11. Install flushometer-valve, water-supply fitting on each supply to each urinal.
12. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
13. Install lever-handle flushometer valves for accessible urinals with handle mounted on open side of compartment.
14. Install actuators in locations easily reachable for people with disabilities.
15. Install new batteries in battery-powered, electronic-sensor mechanisms.
16. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Install deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
17. Seal joints between urinals, walls, and floors using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to urinal color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

E. Water Closet Installation:
1. Install water closets level and plumb in accordance with roughing-in drawings.
2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
3. Install accessible, wall-mounted water closets at mounting height in accordance with ICC A117.1.
4. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
5. Use carrier supports with waste-fitting assembly and seal.
6. Install floor-mounted, back-outlet water closets, attached to building floor substrate, onto waste-fitting seals; and attach to support.
7. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals, and affix to building substrate.
8. Measure support height installation from finished floor, not structural floor.
9. Install flushometer-valve, water-supply fitting on each supply to each water closet.
10. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
11. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
12. Install actuators in locations easily reachable for people with disabilities.
13. Install new batteries in battery-powered, electronic-sensor mechanisms.
14. Install toilet seats on water closets.
15. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Install deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
16. Seal joints between water closets, walls, and floors using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to water-closet color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

F. Wash Fountain Installation:
1. Install wash fountains level and plumb in accordance with roughing-in drawings.
2. Set freestanding wash fountains on floor.

3. Install off-floor carrier supports, affixed to building substrate, for wall-mounted wash fountains.
4. Install accessible, wall-mounted wash fountains at mounting height in accordance with ICC A117.1.
5. Install water-supply piping with shutoff valve on each supply to each wash fountain faucet. Use ball or gate valves if supply stops are not specified with wash fountain. Comply with valve requirements specified in Section 220523 "General Duty Valves for Plumbing Piping." Install stops/valves in locations that are accessible for ease of operation.
6. Install trap and waste piping on each drain outlet of each wash fountain to be connected to sanitary drainage system.
7. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
8. Seal joints between wash fountains, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
9. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.03 INSTALLATION OF PIPING CONNECTIONS

A. Connect plumbing fixtures with water supplies and soil, waste, and vent piping. Use size fittings required to match plumbing fixtures.
B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
C. Comply with soil, waste, and vent piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."
D. Install protective-shielding pipe covers and enclosures on exposed supplies and waste piping of accessible plumbing fixtures. Comply with requirements in Section 220719 "Plumbing Piping Insulation."
E. Where installing piping adjacent to water closets and urinals, allow space for service and maintenance.

3.04 INSTALLATION OF ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
C. Install electrical devices furnished by manufacturer, but not factory mounted in accordance with NFPA 70 and NECA 1.
D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
    1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
    2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least [**1/2 inch**] <**Insert dimensions**> high.

3.05 INSTALLATION OF CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.06 ADJUSTING

A. Operate and adjust plumbing fixtures and controls. Replace damaged and malfunctioning plumbing fixtures, fittings, and controls.
B. Adjust water pressure at faucets to produce proper flow.
C. Adjust water pressure at shower valves to produce proper flow.
D. Adjust water pressure at flushometer valves to produce proper flow.
E. Install new batteries in battery-powered, electronic-sensor mechanisms.

3.07 CLEANING AND PROTECTION

A. After completing installation of plumbing fixtures, inspect and repair damages finishes. Replace any fixtures unable to be repaired to the satisfaction of the [**Architect**] [**Owner**].
B. Clean plumbing fixtures and associated faucets, valves, flushometer valves, and fittings with manufacturers' recommended cleaning methods and materials.
C. Provide protective covering for installed plumbing fixtures and associated faucets, valves, flushometer valves, and fittings.
D. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

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SECTION 230513
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.03 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

2.01 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

2.02 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet 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.

2.03 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
   2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

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.

2.04 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

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-Frequency 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. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.05 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 type.

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.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

SECTION 230517
SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Sleeves without waterstop.
   2. Sleeves with waterstop.
   3. Stack-sleeve fittings.
   4. Sleeve-seal systems.
   5. Grout.
   6. Silicone sealants.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 SLEEVES WITHOUT WATERSTOP

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends.

B. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.

C. Steel Sheet Sleeves: ASTM A653/A653M, 0.0239-inch minimum thickness; hot-dip galvanized, round tube closed with welded longitudinal joint.

D. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

E. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.02 SLEEVES WITH WATERSTOP

A. Description: Manufactured galvanized steel, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.

2.03 STACK-SLEEVE FITTINGS

A. Description: Manufactured, Dura-coated or Duco-coated galvanized cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with setscrews.

2.04 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
   1. Designed to form a hydrostatic seal.
   2. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
   3. Pressure Plates: Composite plastic
   4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.05 GROUT

A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000 psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.06 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant.
   1. Standard: ASTM C920, Type S, Grade NS, Class 25, Use NT.
B. Silicone, S, P, T, NT: Single-component, 25, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant.
   1. Standard: ASTM C920, Type S, Grade P, Class 25, Uses T and NT.
C. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.01 INSTALLATION OF SLEEVES - GENERAL

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 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 above finished floor level.
   3. Using grout or silicone sealant, seal 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 annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.
E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.02 INSTALLATION OF SLEEVES WITH WATERSTOP

A. Install sleeve with waterstop as new walls and slabs 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 or silicone sealant, seal space around outside of sleeves.

3.03 INSTALLATION OF STACK-SLEEVE FITTINGS

A. Install stack-sleeve fittings in new slabs as slabs are constructed.
   1. Install fittings that are large enough to provide 1/4-inch 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 Section 076200 "Sheet Metal Flashing and Trim."

3. Install section of cast-iron soil pipe to extend sleeve to 3 inches 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 waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.04 INSTALLATION OF SLEEVE-SEAL SYSTEMS

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building, and passing through exterior walls.

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.

3.05 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
2. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

B. Prepare test and inspection reports.

3.06 SLEEVE SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:
1. Exterior Concrete Walls above and below Grade:
a. Sleeves with waterstops.
1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
2. Concrete Slabs-on-Grade:
a. Sleeves with waterstops.
1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs above Grade:
a. Sleeves with waterstops or stack-sleeve fittings.
4. Interior Walls and Partitions:
a. Sleeves without waterstops.

END OF SECTION

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SECTION 230518
ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Escutcheons.
   2. Floor plates.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel with polished, chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

D. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed hinge; and spring-clip fasteners.

2.02 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.01 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.
      b. Chrome-Plated Piping: One-piece steel with polished, chrome-plated finish.
      c. Insulated Piping: One-piece steel with polished, chrome-plated finish.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.
      e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.
      f. Bare Piping in Unfinished Service Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
      g. Bare Piping in Equipment Rooms: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.

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: Split floor plate.
   2. Existing Piping to Remain: Split floor plate.

3.02 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION

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SECTION 230519
METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Thermometers, light activated.
2. Thermowells.
3. Pressure gauges, dial type.
4. Gauge attachments.
5. Test plugs.
6. Test-plug kits.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.03 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gauges to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.01 THERMOMETERS, LIGHT ACTIVATED

A. Thermometers, Light Activated - Direct Mounted:
1. Case: Plastic, 7-inch nominal size unless otherwise indicated.
2. Scale Divisions: Deg. F.
3. Case Form: Adjustable angle.
4. Connector: 1-1/4 inches,with ASME B1.1 or ASME B1.20.1 screw threads to fit thermowell.
5. Stem: Aluminum and of length to suit installation.
   a. Design for Air-Duct Installation: With ventilated shroud.
   b. Design for Thermowell Installation: Bare stem.
6. Display: Digital.
7. Accuracy: Plus or minus 1 deg F.

2.02 THERMOWELLS

A. Thermowells:
1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
3. Material for Use with Copper Tubing: CNR.
4. Material for Use with Steel Piping: CRES.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, with ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.03 PRESSURE GAUGES, DIAL TYPE

A. Pressure Gauges, Dial Type - Direct Mounted, Metal Case:
1. Standard: ASME B40.100.
2. Case: Sealed type; cast aluminum or drawn steel, 6-inch nominal diameter.
3. Pressure-Element Assembly: Bourdon tube.

4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2,ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanent scale markings graduated in psi.
7. Pointer: Dark-colored metal.
8. Window: Glass
9. Ring: Metal.
10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.04 GAUGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and porous-metal-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.05 TEST PLUGS

A. Description: Test-station fitting made for insertion in piping tee fitting.

B. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

C. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

D. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

E. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.06 TEST-PLUG KITS

A. Furnish one test-plug kit(s) containing one thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

B. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.

C. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch-diameter dial and probe. Dial range shall be at least 0 to 200 psig.

D. Carrying Case: Metal or plastic, with formed instrument padding.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at the most readable position.

G. Install valve and snubber in piping for each pressure gauge for fluids (except steam).

H. Install test plugs in piping tees.

I. Install flow indicators in piping systems in accessible positions for easy viewing.

J. Install thermometers in the following locations:
1. Supply and return of each hydronic zone.
2. Inlet and outlet of hydronic boiler.

K. Install pressure gauges in the following locations:
1. Discharge of each pressure-reducing valve.

2. Suction and discharge of each pump.

3.02 CONNECTIONS

A. Install meters and gauges adjacent to machines and equipment to allow space for service and maintenance of meters, gauges, machines, and equipment.

3.03 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gauges to proper angle for best visibility.

3.04 THERMOMETER SCHEDULE

A. Thermometers shall be the following:

1. Direct-mounted, light-activated type.

3.05 PRESSURE-GAUGE SCHEDULE

A. Pressure gages shall be the following:

1. Sealed, direct-mounted, metal case.
2. END OF SECTION 230519

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SECTION 230523.12
BALL VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Bronze ball valves.

1.02 DEFINITIONS

A. CWP: Cold working pressure.
B. RPTFE: Reinforced polytetrafluoroethylene.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.04 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 ball valves open to minimize exposure of functional surfaces.
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 operating handles or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

A. ASME Compliance:
   1. ASME B1.20.1 for threads for threaded-end valves.
   2. ASME B16.18 for solder-joint connections.
   3. ASME B31.9 for building services piping valves.
B. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
C. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
D. Valve Sizes: Same as upstream piping unless otherwise indicated.
E. Valve Actuator Types:
   1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
   2. Hand Lever: For quarter-turn valves smaller than NPS 4.
F. Valves in Insulated Piping:
   1. Provide 2-inch extended neck stems.
   2. Extended operating handles with nonthermal-conductive covering material, and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
   3. Memory stops that are fully adjustable after insulation is applied.
G. Valve Bypass and Drain Connections: MSS SP-45.

2.03 BRONZE BALL VALVES

A. Bronze Ball Valves, Two Piece with Full Port and Stainless Steel Trim, Threaded or Soldered Ends:
   1. Standard: MSS SP-110.

2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Two piece.
5. Body Material: Bronze.
6. Ends: Threaded, sweat or o-ring compression (Pro-Press) type.
7. Seats: PTFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Full.

PART 3 - EXECUTION

3.01 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. Remove defective valves from site.

3.02 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow space for service, maintenance, and equipment removal without system shutdown.

B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full valve actuation movement.

F. Valve Tags: Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

G. Adhere to manufacturer's written installation instructions.

3.03 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 exhibiting leakage.

3.04 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified SWP classes or CWP ratings are unavailable, provide the same types of valves with higher SWP classes or CWP ratings.

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.

3.05 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze ball valves, two piece, with stainless-steel trim, full port, threaded, solder, or press connection-joint ends.

B. Pipe NPS 2-1/2 and Larger:

1. Steel ball valves, Class 150.

END OF SECTION

SECTION 230523.14
CHECK VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Bronze swing check valves.

1.02 DEFINITIONS

A. CWP: Cold working pressure.
B. EPDM: Ethylene-propylene-diene monomer.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.04 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, press connections, and weld ends.
   3. 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 stems or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

A. ASME Compliance:
   1. ASME B1.20.1 for threads for threaded-end valves.
   2. ASME B16.1 for flanges on iron valves.
   3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   4. ASME B16.18 for solder joint.
   5. ASME B31.9 for building services piping valves.
B. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.
D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
E. Valve Sizes: Same as upstream piping unless otherwise indicated.
F. Valve Bypass and Drain Connections: MSS SP-45.

2.03 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Bronze Disc, Class 125:
   1. Description:
      a. Standard: MSS SP-80, Type 3.
      b. CWP Rating: 200 psig.
      c. Body Design: Horizontal flow.
      d. Body Material: ASTM B62, bronze.
      e. Ends: Threaded.
      f. Disc: Bronze.

PART 3 - EXECUTION

3.01 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 press fittings to verify they have been properly pressed.
E. Do not attempt to repair defective valves; replace with new valves.

3.02 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
B. Provide support of piping adjacent to valves such that no force is imposed upon valves.
C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.
D. Install valves with stem at or above center of pipe.
E. Install valves in position that does not project into aisles or block access to other equipment.
F. Install valves in position to allow full stem and manual operator movement.
G. Verify that joints of each valve have been properly installed and sealed to ensure that there is no leakage or damage.
H. Install check valves for proper direction of flow and as follows:
    1. Swing Check Valves: In horizontal position with hinge pin level.
I. Install valve tags. Comply with requirements for valve tags and schedules in Section 230553 "Identification for HVAC Piping and Equipment."
J. Adhere to manufacturer's written installation instructions.

3.03 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.

3.04 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 1-1/2 and Smaller:
    1. Bronze Valves: May be provided with solder-joint or press ends instead of threaded ends.
    2. Bronze swing check valves with bronze disc, Class 125.

END OF SECTION

SECTION 230529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Metal pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Fiberglass pipe hangers.
   4. Metal framing systems.
   5. Fiberglass strut systems.
   6. Thermal-hanger shield inserts.
   7. Fastener systems.
   8. Pipe stands.
   9. Equipment stands.
   10. Equipment supports.

B. Related Requirements:
   1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
   3. Section 230548.13 "Vibration Controls for HVAC" for vibration isolation devices.
   4. Section 233113 "Metal Ducts" for duct hangers and supports.
   5. The Read Mountain Fire Department and E-911 fire station building is a Risk Category IV facility with seismic importance factor 1.5. A Delegated Design Submittal is required to ensure that all systems and equipment are installed with the appropriate Seismic Controls in accordance with Standard ASCE 7-22, Chapter 13 – Seismic Design for Nonstructural Components. Engage a qualified Professional Engineer licensed in the Commonwealth of Virginia to design the seismic control system.
   6. Seismic Design Submittal is to include:
      a. Seismic Design Calculations used to properly select seismic-restraint devices, fasteners, and anchorage.
      b. Equipment manufacturer’s written certification for each designated seismic device and system, stating that the protected system will remain operable following the design earthquake.
   7. Engage a factory-authorized service representative to perform tests and inspect components, assemblies, and equipment installations, including connections.
   8. Prepare test and inspection reports after removal and replacement of any malfunctioning devices and successful retesting.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
   1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

2.02 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
   3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
   5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe and Tube Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
   2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel.

2.03 TRAPEZE PIPE HANGERS

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

2.04 PLASTIC PIPE HANGERS

A. Description: Similar to MSS SP-58, Types 1 through 58, factory-fabricated steel pipe hanger except hanger is made of plastic.

B. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.

C. Flammability: ASTM D635, ASTM E84, and UL 94.

2.05 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:
   1. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
   2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
   3. Channels: Continuous slotted carbon steel channel with inturned lips.
   4. Channel Width: Selected for applicable load criteria.
   5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
   6. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.
   7. Metallic Coating: Electroplated zinc.

B. Non-MFMA Manufacturer Metal Framing Systems:
   1. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
   2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
   3. Channels: Continuous slotted stainless steel channel with inturned lips.
   4. Channel Width: Select for applicable load criteria.
   5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
   6. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.
   7. Metallic Coating: Plain.

2.06 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Indoor Applications: Zinc-coated steel.
2. Outdoor Applications: Stainless steel.

2.07 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand:

1. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
2. Base: Single, vulcanized rubber, molded polypropylene, or poly carbonate.
3. Hardware: Galvanized steel or polycarbonate.
4. Accessories: Protection pads.

C. Low-Profile, Single Base, Single-Pipe Stand:

1. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
3. Vertical Members: Two, stainless-steel, continuous-thread 1/2-inch rods.
4. Horizontal Member: Adjustable horizontal, stainless-steel pipe support channels.
5. Pipe Supports: Roller.
6. Hardware: Stainless steel.
7. Accessories: Protection pads.
8. Height: 12 inches above roof.

D. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.08 EQUIPMENT SUPPORTS

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

2.09 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.

F. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.01 APPLICATION

A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

B. 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.

3.02 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. 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 for individual pipe hangers.
2. Field fabricate from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

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

D. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

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

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

H. Install hangers and supports to allow controlled thermal and seismic 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.

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

J. 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 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.

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

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

M. Insulated Piping:

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 allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4and larger if pipe is installed on rollers.
3. 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 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   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.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.03 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 bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.04 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/D1.1M 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 so contours of welded surfaces match adjacent contours.

3.05 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.

3.06 PAINTING

A. Touchup: 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 a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

C. All steel supporting exterior ductwork exposed to weather shall be painted white with two coats of rust-preventative enamel paint after installation.

3.07 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 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 carbon-steel pipe hangers and supports and metal framing systems and attachments for general service applications.

F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

H. Use thermal-hanger shield inserts for insulated piping and tubing.

I. 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 up to 1050 deg F, pipes NPS 4 to NPS 24, 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 36, 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 8.
   10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
   11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
   12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.

13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. 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 or carbon-steel plate.
15. 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 or carbon-steel plate, and with U-bolt to retain pipe.
16. 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.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

J. 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 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

K. 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 for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F 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 piping installations.

L. 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.
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.
    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.

M. 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.

N. 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.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.

8. 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.

O. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION

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SECTION 230548.13
VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Elastomeric isolation pads.
   2. Open-spring isolators.
   3. Elastomeric hangers.
   4. Spring hangers.
   5. Post-installed concrete anchors.
   6. Concrete inserts.
   7. Restrained isolation roof-curb rai

1.03 DEFINITIONS

A. IBC: International Building Code.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

B. Related Requirements:
   1. The Read Mountain Fire Department and E-911 fire station building is a Risk Category IV facility with seismic importance factor 1.5. A Delegated Design Submittal is required to ensure that all systems and equipment are installed with the appropriate Seismic Controls in accordance with Standard ASCE 7-22, Chapter 13 – Seismic Design for Nonstructural Components. Engage a qualified Professional Engineer licensed in the Commonwealth of Virginia to design the seismic control system.
   2. Seismic Design Submittal is to include:
      a. Seismic Design Calculations used to properly select seismic-restraint devices, fasteners, and anchorage.
      b. Equipment manufacturer's written certification for each designated seismic device and system, stating that the protected system will remain operable following the design earthquake.
   3. Engage a factory-authorized service representative to perform tests and inspect components, assemblies, and equipment installations, including connections.
   4. Prepare test and inspection reports after removal and replacement of any malfunctioning devices and successful retesting.

PART 2 - PRODUCTS

2.01 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
   1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
   2. Size: Factory or field cut to match requirements of supported equipment.
   3. Minimum deflection as indicated on Drawings.
   4. Pad Material: Oil- and water-resistant rubber.
   5. Infused nonwoven cotton or synthetic fibers.
   6. Load-bearing metal plates adhered to pads.

7. Sandwich-Core Material: Resilient and elastomeric.
   a. Infused nonwoven cotton or synthetic fibers.

2.02 OPEN-SPRING ISOLATORS

A. 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 steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psi.
   6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
   7. Minimum deflection as indicated on Drawings.

2.03 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:
   1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
   2. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.
   3. Minimum deflection as indicated on Drawings.

2.04 SPRING HANGERS

A. 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. Minimum deflection as indicated on Drawings.
   6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
   9. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.05 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:
   1. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.

B. Adhesive Anchor Bolts:

1. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

C. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp that is not vibration isolated.
1. Undercut expansion anchors are permitted.

2.06 RESTRAINED ISOLATION ROOF-CURB RAILS

A. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment.

B. Upper Frame: Shall provide continuous and captive support for equipment.

C. Lower Support Assembly: Shall be formed sheet metal section containing adjustable and removable steel springs that support upper frame. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials and shall be insulated with a minimum of 2 inches of rigid glass-fiber insulation on inside of assembly.
1. Adjustable, restrained-spring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with integrity of roof.

D. 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.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and equipment to receive vibration isolation devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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.

3.02 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

3.03 INSTALLATION OF VIBRATION CONTROL DEVICES

A. Provide vibration control devices for the following:
1. Fans suspended from structure.
2. Air handling units.
3. Inline pumps.
4. Remote air-cooled condensers.
5. Air terminal units as noted in schedules on drawings.

B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

C. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

D. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

F. Post-Installed Concrete Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.04 ACCOMMODATION OF DIFFERENTIAL MOTION

A. Provide flexible connections in piping systems where they cross structural joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties" for piping flexible connections.

3.05 ADJUSTING

A. Adjust isolators after system is at operating weight.

END OF SECTION

SECTION 230553
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

1.01 SUMMARY

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

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.
B. Valve-numbering scheme.
C. Valve Schedules: Provide for each piping system. Include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS

A. Plastic Labels for Equipment:
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.
   2. Letter and Background Color: As indicated for specific application under Part 3.
   3. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
   4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of 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.
   6. Fasteners: Stainless steel rivets or self-tapping screws.
   7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.
C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.
B. Letter Color: White.
C. Background Color: Red.
D. Maximum Temperature: Able to withstand temperatures of up to 160 deg 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 of 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-taping 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.

2.03 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:

1. Flow-Direction Arrows: Include flow-direction arrows on main distribution piping. Arrows may be either integral with label or applied separately.
2. Lettering Size: At least 1/2 inch for viewing distances of up to 72 inches and proportionately larger lettering for greater viewing distances.

2.04 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Black.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg 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 of 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. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings. Also include the following:

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.

2.05 VALVE TAGS

A. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link chain.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch 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. Include valve-tag schedule in operation and maintenance data.

2.06 WARNING TAGS

A. Description: 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: Reinforced grommet and wire or string.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety-yellow background with black lettering.

PART 3 - EXECUTION

3.01 PREPARATION

A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.02 INSTALLATION, GENERAL REQUIREMENTS

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.

3.03 INSTALLATION OF EQUIPMENT LABELS, WARNING SIGNS, AND LABELS

A. Permanently fasten labels on each item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.04 INSTALLATION OF PIPE LABELS

A. Pipe Label Locations: 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 fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of 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 along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

B. Flow-Direction Arrows: Use arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

C. Pipe-Label Color Schedule:

1. Natural Gas Piping: Black letters on an ANSI Z535.1 safety-yellow background.
2. Heating Water Piping: White letters on an ANSI Z535.1 safety-green background.
3. Refrigerant Piping: White letters on an ANSI Z535.1 safety-blue background.

3.05 INSTALLATION OF DUCT LABELS

A. Install plastic-laminated duct labels showing service and flow direction with permanent adhesive on air ducts.

1. Provide labels in the following color codes:
   a. For air supply ducts: White letters on blue background.
   b. For air return ducts: White letters on green background.
   c. For exhaust-, outside-, and relief-air ducts: White letters on green background.

B. Locate label near each point where ducts enter into and exit from concealed spaces and at maximum intervals of 40 feet where exposed or are concealed by removable ceiling system.

3.06 INSTALLATION OF VALVE TAGS

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 in the operating and maintenance manual.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below.

1. Valve-Tag Size and Shape:

a. Hot Water: 1-1/2 inches, round.

3.07 INSTALLATION OF WARNING TAGS

A. Attach warning tags, with proper message, to equipment and other items where required.

END OF SECTION

SECTION 230593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Testing, Adjusting, and Balancing of Air Systems:
      a. Constant-volume air systems.
      b. Variable-air-volume systems.
   2. Testing, Adjusting, and Balancing of Hydronic Piping Systems:
      a. Primary-secondary hydronic systems.
   3. Testing, adjusting, and balancing of equipment.
   4. Duct leakage tests verification.
   5. Pipe leakage tests verification.
   6. HVAC-control system verification.

1.03 DEFINITIONS

A. AABC: Associated Air Balance Council.
B. NEBB: National Environmental Balancing Bureau.
C. TAB: Testing, adjusting, and balancing.
D. TABB: Testing, Adjusting, and Balancing Bureau.
E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
F. TDH: Total dynamic head.
G. UFAD: Underfloor air distribution.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
B. Certified TAB reports.
C. Instrument calibration reports, to include the following:
   1. Instrument type and make.
   2. Serial number.
   3. Application.
   4. Dates of use.
   5. Dates of calibration.

1.05 QUALITY ASSURANCE

A. TAB Specialists Qualifications, Certified by AABC:
   1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
   2. TAB Technician: Employee of the TAB specialist and certified by AABC.
B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.01 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.

B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
C. Examine the approved submittals for HVAC systems and equipment.
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 ceiling plenums and underfloor air plenums used for HVAC to verify that they are properly separated from adjacent areas and sealed.
F. Examine equipment performance data, including fan and pump curves.
    1. 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.
    2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
H. Examine test reports specified in individual system and equipment Sections.
I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
K. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.
L. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.
M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
N. Examine system pumps to ensure absence of entrained air in the suction piping.
O. Examine operating safety interlocks and controls on HVAC equipment.
P. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.
Q. 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.

3.02 PREPARATION

A. Prepare a TAB plan that includes the following:
    1. Equipment and systems to be tested.
    2. Strategies and step-by-step procedures for balancing the systems.
    3. Instrumentation to be used.
    4. Sample forms with specific identification for all equipment.
B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
    1. Airside:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
b. Duct systems are complete with terminals installed.
c. Volume, smoke, and fire dampers are open and functional.
d. Clean filters are installed.
e. Fans are operating, free of vibration, and rotating in correct direction.
f. Variable-frequency controllers' startup is complete and safeties are verified.
g. Automatic temperature-control systems are operational.
h. Ceilings are installed.
i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:
a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
b. Piping is complete with terminals installed.
c. Water treatment is complete.
d. Systems are flushed, filled, and air purged.
e. Strainers are pulled and cleaned.
f. Control valves are functioning in accordance with the sequence of operation.
g. Shutoff and balance valves have been verified to be 100 percent open.
h. Pumps are started and proper rotation is verified.
i. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
j. Variable-frequency controllers' startup is complete and safeties are verified.
k. Suitable access to balancing devices and equipment is provided.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in "National Standards for Total System Balance" or [NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

B. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in [**inch-pound (IP)**] [**and**] [**metric (SI)**] units.

3.04 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:
1. Motors.

2. Pumps.
3. Fans and ventilators.
4. Terminal units.
5. Boilers.
6. Unit heaters.
7. Condensing units.
8. Condensers.
9. Air-handling units.
10. Heating and ventilating units.
11. Computer-room air conditioners.
12. Split-system air conditioners.
13. Coils.
14. Fan coil units.

3.05 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross check the summation of required outlet volumes with required fan volumes.
B. Prepare schematic diagrams of systems' Record drawings 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 outdoor-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.

3.06 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 total airflow.
        a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
        b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
        c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    2. Measure fan static pressures as follows:
        a. Measure static pressure directly at the fan outlet or through the flexible connection.
        b. Measure static pressure directly at the fan inlet or through the flexible connection.
        c. Measure static pressure across each component that makes up the air-handling system.
        d. Report artificial loading of filters at the time static pressures are measured.
    3. Review Contractor-prepared shop drawings and Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.

4. Obtain approval from Commissioning Authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. 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 occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.
1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.
1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.07 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:
1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
   a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
   b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
   c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
   d. Adjust controls so that terminal is calling for minimum airflow.

e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
f. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow, so that connected total matches fan selection and simulates actual load in the building.
c. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
d. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

6. Measure fan static pressures as follows:
a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
a. Balance the return-air ducts and inlets.
b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit, and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls Contractor.

9. Verify final system conditions as follows:
a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
b. Re-measure and confirm that total airflow is within design.
c. Re-measure final fan operating data, speed, volts, amps, and static profile.
d. Mark final settings.
e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
f. Verify tracking between supply and return fans.

3.08 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and equipment flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' Record drawings piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check expansion tank for proper setting.

2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
5. Verify that motor controllers are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

D. Measure and record upstream and downstream pressure of each piece of equipment.
E. Measure and record upstream and downstream pressure of pressure-reducing valves.
F. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
1. Check settings and operation of each safety valve. Record settings.

3.09 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first.
B. Balance the secondary circuits after the primary circuits are complete.
C. Adjust pumps to deliver total design flow.
1. Measure total water flow.
a. Position valves for full flow through coils.
b. Measure flow by main flow meter, if installed.
c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
2. Measure pump TDH as follows:
a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
c. Convert pressure to head and correct for differences in gauge heights.
d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
e. With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.
3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

D. Adjust flow-measuring devices installed in mains and branches to design water flows.
1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

E. Adjust flow-measuring devices installed at terminals for each space to design water flows.
1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

F. For systems with pressure-independent valves at terminals:
1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

G. For systems without pressure-independent valves or flow-measuring devices at terminals:
   1. Measure and balance coils by either coil pressure drop or temperature method.
   2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

H. Verify final system conditions as follows:
   1. Re-measure and confirm that total water flow is within design.
   2. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
   3. Mark final settings.

I. Verify that memory stops have been set.

3.10 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer's name, model number, and serial number.
   2. Motor horsepower rating.
   3. Motor rpm.
   4. Phase and hertz.
   5. Nameplate and measured voltage, each phase.
   6. Nameplate and measured amperage, each phase.
   7. Starter size and thermal-protection-element rating.
   8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.11 PROCEDURES FOR AIR-COOLED CONDENSING UNITS

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of compressor(s), fan(s), and motors.

3.12 PROCEDURES FOR AIR-COOLED CONDENSERS

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of fan(s) and motor(s).

3.13 PROCEDURES FOR BOILERS

A. Hydronic Boilers:
   1. Measure and record entering- and leaving-water temperatures.
   2. Measure and record water flow.
   3. Measure and record pressure drop.
   4. Record relief valve(s) pressure setting.
   5. Capacity: Calculate in Btu/h of heating output.
   6. Fuel Consumption: If boiler fuel supply is equipped with flow meter, measure and record consumption.
   7. Efficiency: Calculate operating efficiency for comparison to submitted equipment.
   8. Fan, motor, and motor controller operating data.

3.14 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each hydronic 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. Measure, adjust, and record the following data for each electric heating coil:
1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Air pressure drop.
5. Voltage and amperage input of each phase at full load.
6. Calculated kilowatt at full load.
7. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:
1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant 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. Entering and leaving refrigerant pressure and temperatures.

3.15 DUCT LEAKAGE TESTS

A. Witness the duct leakage testing performed by Installer.
B. Verify that proper test methods are used and that leakage rates are within specified limits.
C. Report deficiencies observed.

3.16 PIPE LEAKAGE TESTS

A. Witness the pipe pressure testing performed by Installer.
B. Verify that proper test methods are used and that leakage rates are within specified limits.
C. Report deficiencies observed.

3.17 HVAC CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:
1. Verify HVAC control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.18 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
1. Supply, Return, and Exhaust Fans and Equipment with Fans: **Plus or minus 10 percent**. If design value is less than 100 cfm, within 10 cfm.

2. Air Outlets and Inlets: Plus or minus 10 percent. If design value is less than 100 cfm, within 10 cfm.
3. Heating-Water Flow Rate: Plus or minus 10 percent. If design value is less than 10 gpm, within 10 percent.
4. Chilled-Water Flow Rate: Plus or minus 10 percent. If design value is less than 10 gpm, within 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.19 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. 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; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:
1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor 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's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans performance forms, including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Heating coil, dry-bulb conditions.
    e. Face and bypass damper settings at coils.

f. Fan drive settings, including settings and percentage of maximum pitch diameter.
g. Inlet vane settings for variable-air-volume systems.
h. Settings for pressure controller(s).
i. Other system operating conditions that affect performance.

16. Test conditions for pump performance forms, including the following:
a. Variable-frequency controller settings for variable-flow hydronic systems.
b. Settings for pressure controller(s).
c. Other system operating conditions that affect performance.

D. 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 outdoor, 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.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units, include the following:
1. Unit Data:
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, and bore.
i. Center-to-center dimensions of sheave and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:
a. Motor make, and frame type and size.
b. Horsepower and speed.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan speed.
d. Inlet and discharge static pressure in inches wg.
e. For each filter bank, filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. List for each internal component with pressure-drop, static-pressure differential in inches wg.
j. Outdoor airflow in cfm.

k. Return airflow in cfm.
l. Outdoor-air damper position.
m. Return-air damper position.

F. 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 o.c.
f. Make and model number.
g. Face area in sq. ft..
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.

G. 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 Btu/h.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and speed.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave and amount of adjustments in inches.
2. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.

b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

H. 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 Btu/h.
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Airflow rate in cfm.
i. Face area in sq. ft..
j. Minimum face velocity in fpm.
2. Test Data (Indicated and Actual Values):
a. Heat output in Btu/h.
b. Airflow rate in cfm.
c. Air velocity in fpm.
d. Entering-air temperature in deg F.
e. Leaving-air temperature in deg F.
f. Voltage at each connection.
g. Amperage for each phase.

I. 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, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.
2. Motor Data:
a. Motor make, and frame type and size.
b. Horsepower and speed.
c. Volts, phase, and hertz.

d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan speed.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

J. 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 fan and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

K. Air-Terminal-Device Reports:

1. Unit Data:
a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft..

2. Test Data (Indicated and Actual Values):
a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

L. 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.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

M. 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 number and serial number.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump speed.
j. Impeller diameter in inches.
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.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

N. Instrument Calibration Reports:

1. Report Data:
a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

PART 4 - END OF SECTION 230566

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SECTION 230713
DUCT INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes insulating the following duct services:
   1. Indoor, concealed supply and outdoor air.
   2. Indoor, exposed supply and outdoor air.
   3. Indoor, concealed return located in unconditioned space.
   4. Indoor, exposed return located in unconditioned space.
   5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
   6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
   7. Outdoor, concealed supply and return.
   8. Outdoor, exposed supply and return.

B. Related Requirements:
   1. Section 230716 "HVAC Equipment Insulation."
   2. Section 230719 "HVAC Piping Insulation."

1.02 ACTION SUBMITTALS

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

1.03 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers are to be marked with the manufacturer's name, appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.04 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork 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.

1.05 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.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
   1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. All Insulation Installed Indoors; Outdoors-Installed Insulation in Contact with Airstream: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

3. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.02 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C534 or ASTM C1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

2.03 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. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

2.04 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
4. Color: White.

2.05 LAGGING ADHESIVES

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

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

2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.06 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

2.07 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.08 TAPES

A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
1. Width: 3 inches.
2. Thickness: 6.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.09 SECUREMENTS

A. Bands:
1. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing seal or closed seal.
2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.

B. Insulation Pins and Hangers:
1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch-diameter shank, length to suit depth of insulation indicated.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
4. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

2.10 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

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

3.02 PREPARATION

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

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct 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. Keep insulation materials dry during application and finishing.

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

H. Install insulation with least number of joints practical.

I. 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 to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

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

K. Install insulation with 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 o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. 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, according to insulation material manufacturer's written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

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

N. 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.

3.04 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
   4. Seal jacket to roof flashing with flashing sealant.

B. 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. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

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

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
   1. Comply with requirements in Section 078413 "Penetration Firestopping."

E. Insulation Installation at Floor Penetrations:
   1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.05 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
   2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Impale insulation over pins and attach speed washers.
   f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not overcompress insulation during installation.
e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.06 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:
   1. Indoor, concealed supply and outdoor air.
   2. Indoor, exposed supply and outdoor air.
   3. Indoor, concealed return located in unconditioned space.
   4. Indoor, exposed return located in unconditioned space.
   5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
   6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
   7. Outdoor, concealed supply and return.
   8. Outdoor, exposed supply and return.

B. Items Not Insulated:
   1. Fibrous-glass ducts.
   2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.

3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.07 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round and rectangular supply-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density. The R-value of the insulation shall meet the requirements of the International Energy Conservation Code 2021 Edition for the service installed.

B. Concealed, round and rectangular return-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density. The R-value of the insulation shall meet the requirements of the International Energy Conservation Code 2021 Edition for the service installed.
   2. Where located in a return air plenum, return duct insulation is not required.

C. Concealed, round and rectangular outdoor-air duct and plenum insulation shall be the following:
   1. Mineral-Fiber Blanket: 3 inches thick and 0.75-lb/cu. ft. nominal density.

D. Concealed, rectangular exhaust-air duct insulation between isolation damper and penetration of building exterior shall be the following:
   1. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density.

E. Exposed, round and rectangular, supply-air duct insulation shall be the following:
   1. Mineral-Fiber Board: 3 inches thick and 2-lb/cu. ft. nominal density. For rectangular duct, provide PVC jacket with color to be selected by architect.

F. Exposed, round and rectangular outdoor-air duct insulation shall be the following:
   1. Mineral-Fiber Board: 3 inches thick and 2-lb/cu. ft. nominal density. For rectangular duct, provide PVC jacket with color to be selected by architect. For round duct see Section 233113 “Metal Ducts”.

3.08 OUTDOOR DUCT INSULATION SCHEDULE

A. Concealed, round and rectangular supply-, and return-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 3 inches thick and 0.75-lb/cu. ft. nominal density. The R-value of the insulation shall meet the requirements of the International Energy Conservation Code 2021 Edition for the service installed.

B. Exposed, round and rectangular supply-, and return-air duct insulation shall be the following:
   1. Thermaduct OD, Pre-Insulated, Impact Resistant, cladded duct system with R-8.1 panel and 3½ inch, 3.5-lb/cu. Ft. density closed cell rigid thermoset resin bonded on both sides to factory applied 0.001 inch aluminum foil facing reinforced with fiberglass scrim and factory bonded to UV stable, IR reflective, 1000-micron, impact resistant titanium infused vinyl cladding. Installation shall be in strict accordance with manufacturers instructions. The R-value of the insulation shall meet the requirements of the International Energy Conservation Code 2021 Edition for the service installed.

PART 4 - END OF SECTION 230713

1.

SECTION 230719
HVAC PIPING INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes insulation for HVAC piping systems.

B. Related Requirements:

1. Section 230713 "Duct Insulation" for duct insulation.
2. Section 230716 "HVAC Equipment Insulation" for equipment insulation.

1.02 ACTION SUBMITTALS

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

1.03 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program, certified by the Department of Labor, Bureau of Apprenticeship and Training.

1. Obtain Architect's approval of mockups before starting insulation application.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. The packaging is to include name of manufacturer, fabricator, type, description, and size, as well as ASTM standard designation, and maximum use temperature.

1.05 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping 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.

1.06 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.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to 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 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.

2.02 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials are applied.

B. Products do not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come into contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.
E. Foam insulation materials do 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. Block Insulation: ASTM C 552, Type I.
    2. Special-Shaped Insulation: ASTM C 552, Type III.
    3. Board Insulation: ASTM C 552, Type IV.
    4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
    5. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
    6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
G. Flexible Elastomeric: Closed-cell, or expanded-rubber materials; suitable for maximum use temperature between minus 70 deg F and 220 deg F. Comply with ASTM C534/C534M, Type I, for tubular materials, Type II for sheet materials.
H. Mineral-Fiber, Preformed Pipe Insulation:
    1. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.03 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.04 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: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
E. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

2.05 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.
1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
2. Service Temperature Range: Minus 50 to plus 220 deg F.
3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
4. Color: White.

2.06 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.07 SEALANTS

A. Cellular-Glass, Phenolic, and Polyisocyanurate Joint Sealants:

B. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.08 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.09 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Metal Jacket:
1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
a. Sheet and roll stock ready for shop or field sizing.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
e. Factory-Fabricated Fitting Covers:
1) Same material, finish, and thickness as jacket.

2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.10 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Width: 2 inches.
2. Thickness: 6 mils.
3. Adhesion: 64 ounces force/inch in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.

2.11 SECUREMENTS

A. Bands:
1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch thick, 3/4 inch wide with wing seal or closed seal.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.02 PREPARATION

A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

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

3.03 GENERAL INSTALLATION REQUIREMENTS

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

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of 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. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

J. 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 to tightly join 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.

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

L. Install insulation with 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 o.c.
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 4 inches o.c.
   a. For below-ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, 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.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

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

O. 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.

P. 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.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.04 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. 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. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

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 Section 078413 "Penetration Firestopping" for 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 Section 078413 "Penetration Firestopping."

3.05 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more 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, flanges, unions, 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. Butt 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. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
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.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. 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.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.06 INSTALLATION OF CELLULAR-GLASS INSULATION

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 jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with jackets on below-ambient services, do not staple longitudinal tabs. Instead, 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 prefabricated 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 that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
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 prefabricated sections of same material as that of 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 or routed sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install prefabricated 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.

3.07 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
1. Install 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 sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install sections of pipe insulation and miter if required in accordance with manufacturer's written instructions.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install prefabricated valve covers manufactured of same material as that of pipe insulation when available.
2. When prefabricated valve covers are not available, install cut sections of pipe and sheet insulation to valve body. 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.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.08 INSTALLATION OF MINERAL-FIBER INSULATION

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. Instead, 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 mineral-fiber 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.

3.09 INSTALLATION OF FIELD-APPLIED JACKETS

A. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.10 PIPING INSULATION SCHEDULE, GENERAL

A. Insulation conductivity and thickness per pipe size comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. 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.

C. 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. Drainage piping located in crawlspaces.

3.11 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:
1. All Pipe Sizes: Insulation shall be the following:
a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.

B. Heating-Hot-Water Supply and Return, 200 Deg F and Below:
1. NPS 12 and Smaller: Insulation shall be[**one of**] the following:
a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.

C. Refrigerant Suction and Hot-Gas Piping and Tubing:
1. All Pipe Sizes: Insulation shall be the following:
a. Flexible Elastomeric: 1 inch thick. Pre-insulated linesets are acceptable.

3.12 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping and Tubing:
1. All Pipe Sizes: Insulation shall be the following:
a. Flexible Elastomeric: 1 inches thick.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed and Exposed:

1. None – ASJ to match factory jacket to form a complete vapor barrier.

3.14 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed and Exposed:

1. Aluminum, Corrugated: 0.020 inch thick.

END OF SECTION

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SECTION 230923
DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Direct digital control (DDC) system for HVAC.

1.02 ACTION SUBMITTALS

A. Product Data:
   1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
   3. Product description with complete technical data, performance curves, and product specification sheets.
   4. Installation, operation, and maintenance instructions including factors effecting performance.
   5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
      a. DDC controllers.
      b. Enclosures.
      c. Electrical power devices.
      d. Accessories.
      e. Instruments.
      f. Control dampers and actuators.
      g. Control valves and actuators.
   6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
   7. Each submitted piece of product literature to clearly cross reference specification and drawings that submittal is to cover.

B. Shop Drawings:
   1. General Requirements:
      a. Include cover drawing with Project name, location, Owner, Architect, Contractor, and issue date with each Shop Drawings submission.
      b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
   2. Include plans, elevations, sections, and mounting details where applicable.
   3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   4. Detail means of vibration isolation and show attachments to rotating equipment.
   5. Plan Drawings indicating the following:
      a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork, and piping.
      b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
      c. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.

6. Schematic drawings for each controlled HVAC system indicating the following:
   a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
   b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
   c. A graphic showing location of control I/O in proper relationship to HVAC system.
   d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
   e. Unique identification of each I/O that to be consistently used between different drawings showing same point.
   f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.
   g. Narrative sequence of operation.
   h. Graphic sequence of operation, showing all inputs and output logical blocks.
7. Control panel drawings indicating the following:
   a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
   b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates, and allocated spare space.
   c. Front, rear, and side elevations and nameplate legend.
   d. Unique drawing for each panel.
8. DDC system network riser diagram indicating the following:
   a. Each device connected to network with unique identification for each.
   b. Interconnection of each different network in DDC system.
   c. For each network, indicate communication protocol, speed, and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
9. DDC system electrical power riser diagram indicating the following:
   a. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
   b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
   c. Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
   d. Power wiring type and size, race type, and size for each.

1.03 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
      b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
      c. As-built versions of submittal Product Data.
      d. Names, addresses, email addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.

e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
g. Engineering, installation, and maintenance manuals that explain how to do the following:
    1) Design and install new points, panels, and other hardware.
    2) Perform preventive maintenance and calibration.
    3) Debug hardware problems.
    4) Repair or replace hardware.
h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and databases on electronic media.
j. List of recommended spare parts with part numbers and suppliers.
k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
m. Licenses, guarantees, and warranty documents.
n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
o. Owner training materials.

1.04 WARRANTY

A. Special Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.
    1. Adjust, repair, or replace failures at no additional cost or reduction in service to Owner.
    2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
        a. Install updates only after receiving Owner's written authorization.
    3. Perform warranty service during normal business hours and commence within 24 hours of Owner's warranty service request.
    4. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

A. Trane Tracer Summit or SC.

2.02 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.
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.

2.03 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths complying with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 50 or less.

B. Environmental Conditions for Controllers, Gateways, and Routers:
   1. Products to operate without performance degradation under ambient environmental temperature, pressure, and humidity conditions encountered for installed location.
      a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure to be internally insulated, electrically heated, cooled, and ventilated as required by product and application.
   2. Protect products with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House products not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location dictates the following NEMA 250 enclosure requirements:
      a. Outdoors, Protected: Type 12.
      b. Outdoors, Unprotected: Type 4.
      c. Indoors, Heated with Filtered Ventilation: Type 1.
      d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
      e. Indoors, Heated and Air-Conditioned: Type 1.
      f. Mechanical Equipment Rooms:
         1) Chiller and Boiler Rooms: Type 12.
         2) Air-Moving Equipment Rooms: Type 12.
      g. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 12.
      h. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4X.

C. Environmental Conditions for Instruments and Actuators:
   1. Instruments and actuators to operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
      a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure is internally insulated, electrically heated, cooled**,** and ventilated as required by instrument and application.
   2. Protect instruments, actuators, and accessories with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House instruments and actuators not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location is to dictate the following NEMA 250 enclosure requirements:
      a. Outdoors, Protected: Type 12.
      b. Outdoors, Unprotected: Type 4X.
      c. Indoors, Heated with Filtered Ventilation: Type 1.
      d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
      e. Indoors, Heated and Air-conditioned: Type 1.

f. Mechanical Equipment Rooms:
   1) Chiller and Boiler Rooms: Type 12.
   2) Air-Moving Equipment Rooms: Type 12.
g. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 12.
h. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4X.

2.04 DDC CONTROLLERS

A. DDC system consisting of a combination of network controllers, programmable application controllers, and application-specific controllers to satisfy performance requirements indicated.
B. DDC controllers to perform monitoring, control, energy optimization, and other requirements indicated.
C. DDC controllers are to use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.
D. Each DDC controller is capable of full and complete operation as a completely independent unit and as a part of DDC system wide distributed network.
E. Environment Requirements:
   1. Controller hardware suitable for anticipated ambient conditions.
   2. Controllers located in conditioned space rated for operation at 32 to 120 deg F.
   3. Controllers located outdoors rated for operation at 40 to 150 deg F.
F. Power and Noise Immunity:
   1. Operate controller at 90 to 110 percent of nominal voltage rating and perform an orderly shutdown below 80 percent of nominal voltage.
   2. Protect against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.
G. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:
   1. Network Controllers:
      a. 10 percent of each AI, AO, BI, and BO point connected to controller.
      b. Minimum Spare I/O Points per Controller:
         1) AIs: Two.
         2) AOs: Two.
         3) BIs: Three.
         4) BOs: Three.
   2. Programmable Application Controllers:
      a. 10 percent of each AI, AO, BI, and BO point connected to controller.
      b. Minimum Spare I/O Points per Controller:
         1) AIs: Two.
         2) AOs: Two.
         3) BIs: Three.
         4) BOs: Three.
   3. Application-Specific Controllers:
      a. 10 percent of each AI, AO, BI, and BO point connected to controller.
H. Maintenance and Support: Include the following features to facilitate maintenance and support:
   1. Mount microprocessor components on circuit cards for ease of removal and replacement.
   2. Means to quickly and easily disconnect controller from network.

3. Means to quickly and easily access connect to field test equipment.
4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

I. I/O Point Interface:
1. Connect hardwired I/O points to network, programmable application, and application-specific controllers.
2. Protect I/O points so shorting of point to itself, to another point, or to ground will not damage controller.
3. Protect I/O points from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:
   a. Include monitoring of low-voltage (0 to 10 V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
   b. Compatible with, and field configurable to, sensor and transmitters installed.
   c. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
   d. Signal conditioning including transient rejection for each AI.
   e. Capable of being individually calibrated for zero and span.
   f. Incorporate common-mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.
   g. External conversion resistors are not permitted.
5. AOs:
   a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
   b. Output signals shall have a range of 4 to 20 mA dc as required to include proper control of output device.
   c. Capable of being individually calibrated for zero and span.
   d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.
6. BIs:
   a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.
   b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
   c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.
   d. BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
   e. Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.
7. BOs:
   a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.
      1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference

suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.

2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.

b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.

c. BOs shall be selectable for either normally open or normally closed operation.

d. Include tristate outputs (two coordinated BOs) for control of three-point floating-type electronic actuators without feedback.

2.05 NETWORK CONTROLLERS

A. General:

1. Include adequate number of controllers to achieve performance indicated.
2. Provide one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Include enough memory to support its operating system, database, and programming requirements with spare memory indicated.
4. Share data between networked controllers and other network devices.
5. Operating system of controller to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Include network controllers with a real-time clock.
7. Controller to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller is to assume a predetermined failure mode and generate an alarm notification.
8. Make controllers fully programmable.

B. Communication:

1. Network controllers communicate with other devices on DDC system Level 1 network.
2. Network controller to also perform routing if connected to network of programmable application controllers and application-specific controllers.

C. Operator Interface:

1. Equip controllers with a service communications port for connection to a portable operator's workstation or PDA.
2. Local Keypad and Display:
   a. Equip controller with local keypad and digital display for interrogating and editing data.
   b. Use of keypad and display requires a security password.

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain Basic Input Output System (BIOS) and programming information in event of power loss for at least 96 hours.

2.06 PROGRAMMABLE APPLICATION CONTROLLERS

A. General:

1. Include adequate number of controllers to achieve performance indicated.
2. Provide enough memory to support its operating system, database, and programming requirements with spare memory indicated.

3. Share data between networked controllers and other network devices.
4. Include controller with operating system to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Include controllers with a real-time clock.
6. Controller is to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller assumes a predetermined failure mode and generates an alarm notification.
7. Fully programmable.

B. Communication:
1. Programmable application controllers are to communicate with other devices on network.

C. Operator Interface:
1. Equip controllers with a service communications port for connection to a portable operator's workstation or PDA.
2. Local Keypad and Display:
   a. Equip controller with local keypad and digital display for interrogating and editing data.
   b. Protect use of keypad and display by security password.

D. Serviceability:
1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain BIOS and programming information in event of power loss for at least 72 hours.

2.07 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment or system. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.
1. Capable of standalone operation and continued control functions without being connected to network.
2. Share data between networked controllers and other network devices.

B. Communication: Application-specific controllers are to communicate with other application-specific controllers and devices on network, and to programmable application controllers and network controllers.

C. Operator Interface: Equip controllers with a service communications port for connection to a portable operator's workstation. Connection shall extend to port on space temperature sensor that is connected to controller.

D. Serviceability:
1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.08 CONTROLLER SOFTWARE

A. General:

1. Software applications are to reside and operate in controllers. Edit applications through operator workstations.
2. Identify I/O points by up to 30character point name and up to 16-character point descriptor. Use same names throughout, including at operator workstations.
3. Execute control functions within controllers using DDC algorithms.
4. Configure controllers to use stored default values to ensure fail-safe operation. Use default values when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:
1. Secure operator access using individual security passwords and user names.
2. Passwords restrict operator to points, applications, and system functions as assigned by system manager.
3. Record operator log-on and log-off attempts.
4. Protect from unauthorized use by automatically logging off after last keystroke. Make the delay time operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule is to consist of the following:
1. Weekly Schedules:
   a. Include separate schedules for each day of week.
   b. Each schedule should include capability for start, stop, optimal start, optimal stop, and night economizer.
   c. Each schedule may consist of up to 10 events.
   d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.
2. Exception Schedules:
   a. Include ability for operator to designate any day of the year as an exception schedule.
   b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.
3. Holiday Schedules:
   a. Include capability for operator to define up to 99 special or holiday schedules.
   b. Place schedules on scheduling calendar with ability to repeated each year.
   c. Operator able to define length of each holiday period.

D. System Coordination:
1. Include standard application for proper coordination of equipment.
2. Include operator with a method of grouping together equipment based on function and location.
3. Include groups that may be for use in scheduling and other applications.

E. Binary Alarms:
1. Set each binary point to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:
1. Provide each analog object with both high and low alarm limits.
2. Include capability to automatically and manually disable alarming.

G. Alarm Reporting:
1. Include ability for operators to determine action to be taken in event of an alarm.
2. Route alarms to appropriate operator workstations based on time and other conditions.

3. Include ability for alarms to start programs, print, be logged in event logs, generate custom messages, and display graphics.

H. Remote Communication:
1. Include ability for system to notify operators by phone message, text message, and email in event of an alarm.

I. Maintenance Management: Monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.

J. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

K. Control Loops:
1. Support any of the following control loops, as applicable to control required:
a. Two-position (on/off, open/close, slow/fast) control.
b. Proportional control.
c. Proportional plus integral (PI) control.
d. Proportional plus integral plus derivative (PID) control.
1) Include PID algorithms with direct or reverse action and anti-windup.
2) Algorithm to calculate a time-varying analog value used to position an output or stage a series of outputs.
3) Make controlled variable, set point, and PID gains operator-selectable.
e. Adaptive (automatic tuning).

L. Staggered Start: Prevent all controlled equipment from simultaneously restarting after a power outage. Make the order which equipment (or groups of equipment) is started, along with the time delay between starts, operator-selectable.

M. Anti-Short Cycling:
1. Protect BO points from short cycling.
2. Feature to allow minimum on-time and off-time to be selected.

N. On and Off Control with Differential:
1. Include algorithm that allows BO to be cycled based on a controlled variable and set point.
2. Use direct- or reverse-acting algorithm and incorporate an adjustable differential.

2.09 ENCLOSURES

A. General:
1. House each controller and associated control accessories in single enclosure. Enclosure is to serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies, and transformers.
2. Do not house more than one controller in single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.
5. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
6. Supply each enclosure with complete set of as-built schematics, tubing, and wiring diagrams and product literature located in pocket on inside of door.

B. Internal Arrangement:
1. Arrange internal layout of enclosure to group and protect pneumatic, electric, and electronic components associated with controller, but not an integral part of controller.

2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling, and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 10 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install maximum of two wires on each side of terminal.
9. Include enclosure field electric power supply with toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with line-voltage nominal 20 A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with 5 A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). Nameplates are to have at least 1/4-inch-high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with continuous removable cover.
14. Label each end of cable, wire, and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Environmental Requirements:
1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction, and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
5. Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.
6. Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

2.10 ELECTRICAL POWER DEVICES

A. Control Transformers:
1. Sizing Criteria: Size control transformers for total connected load, plus additional 25 percent of connected load for future spare capacity.
2. Protection: Provide transformers with both primary and secondary fuses.

B. Power-Line Conditioners:
   1. General Power-Line Conditioner Requirements:
      a. Design to ensure maximum reliability, serviceability, and performance.
      b. Overall function of power-line conditioner is to receive raw, polluted electrical power and purify it for use by electronic equipment. Power-line conditioner is to provide isolated, regulated, transient, and noise-free sinusoidal power to loads served.
   2. Standards: NRTL listed per UL 1012.
   3. Performance:
      a. Single phase, continuous, 100 percent duty rated KVA/KW capacity. Design to supply power for linear or nonlinear, high crest factor, resistive and reactive loads.
      b. Automatically regulate output voltage to within 2 percent or better with input voltage fluctuations of plus 10 to minus 20 percent of nominal when system is loaded 100 percent. Use Variable Range Regulation to obtain improved line voltage regulation when operating under less than full load conditions.
         1) At 75 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 35 percent of nominal.
         2) At 50 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 40 percent of nominal.
         3) At 25 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 45 percent of nominal.
      c. With input voltage distortion of up to 40 percent, limit the output voltage sine wave to a maximum harmonic content of 5 percent.
      d. Automatically regulate output voltage to within 2.5 percent when load (resistive) changes from zero percent to 100 percent to zero percent.
      e. Output voltage returns to 95 percent of nominal level within two cycles and to 100 percent within three cycles when the output is taken from no load to full resistive load or vice-versa. Recovery from partial resistive load changes is corrected in a shorter period of time.
      f. K Factor: 30, designed to operate with nonlinear, non-sinusoidal, high crest factor loads without overheating.
      g. Input power factor within 0.95 approaching unity with load power factor as poor as 0.6.
      h. Attenuate load-generated odd current harmonics 23 dB at the input.
      i. Electrically isolate the primary from the secondary. Meet isolation criteria as defined in NFPA 70, Article 250-5D.
      j. Lighting and Surge Protection: Compares to UL 1449 rating of 330 V when subjected to Category B3 (6000 V/3000 A) combination waveform as established by IEEE C62.41.
      k. Common-mode noise attenuation of 140 dB.
      l. Transverse-mode noise attenuation of 120 dB.
      m. With loss of input power for up to 16.6 ms, the output sine wave remains at usable ac voltage levels.
      n. Reliability of 200,000 hours' MTBF.
      o. At full load, when measured at 1-m distance, audible noise is not to exceed 54 dB.
      p. Approximately 92 percent efficient at full load.

4. Transformer Construction:
   a. Ferroresonant, dry type, convection cooled, 600V class. Transformer windings of Class H (220 deg C) insulated copper.
   b. Use a Class H installation system throughout with operating temperatures not to exceed 150 deg C over a 40-deg C ambient temperature.
   c. Configure transformer primary for multi-input voltage. Include input terminals for source conductors and ground.
   d. Manufacture transformer core using M-6 grade, grain-oriented, stress-relieved transformer steel.
   e. Configure transformer secondary in a 240/120-V split with a 208-V tap or straight 120 V, depending on power output size.
   f. Electrically isolate the transformer secondary windings from the primary windings. Bond neutral conductor to cabinet enclosure and output neutral terminal.
   g. Include interface terminals for output power hot, neutral and ground conductors.
   h. Label leads, wires and terminals to correspond with circuit wiring diagram.
   i. Vacuum impregnate transformer with epoxy resin.
5. Cabinet Construction:
   a. Design for panel or floor mounting.
   b. NEMA 250, Type 1, general-purpose, indoor enclosure.
   c. Manufacture the cabinet from heavy gauge steel complying with UL 50.
   d. Include a textured baked-on paint finish.

C. DC Power Supply:
1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
2. Enclose circuitry in a housing.
3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
4. Performance:
   a. Output voltage nominally 25-V dc within 5 percent.
   b. Output current up to 100 mA.
   c. Input voltage nominally 120-V ac, 60 Hz.
   d. Load regulation within 0.5 percent from zero- to 100-mA load.
   e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
   f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.11 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.
1. All control wiring shall be as required by the controls system manufacturer.

2.12 RACEWAYS

A. Metal Conduits, Tubing, and Fittings:
1. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. GRC: Comply with NEMA ANSI C80.1 and UL 6.
3. ARC: Comply with NEMA ANSI C80.5 and UL 6A
4. IMC: Comply with NEMA ANSI C80.6 and UL 1242.
5. EMT: Comply with NEMA ANSI C80.3 and UL 797.
6. FMC: Comply with UL 1; zinc-coated steel or aluminum.
7. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

8. Fittings for Metal Conduit: Comply with NEMA ANSI FB 1 and UL 514B.
   a. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
   b. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
   c. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.
9. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

B. Nonmetallic Conduits, Tubing, and Fittings:
1. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ENT: Comply with NEMA TC 13 and UL 1653
3. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
4. LFNC: Comply with UL 1660.
5. Rigid HDPE: Comply with UL 651A.
6. Continuous HDPE: Comply with UL 651A.
7. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.
8. RTRC: Comply with UL 2515A and NEMA TC 14.
9. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
10. Fittings for LFNC: Comply with UL 514B.

2.13 CONTROL POWER WIRING AND RACEWAYS

A. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" electrical power conductors and cables.
B. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

2.14 ACCESSORIES

A. Instrument Enclosures:
1. Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.
2. NRTL listed and labeled to UL 50.
3. Sized to include at least 25 percent spare area on subpanel.
4. Instrument(s) mounted within enclosure on internal subpanel(s).
5. Enclosure face with engraved, laminated phenolic nameplate for each instrument within enclosure.
6. Enclosures housing pneumatic instruments shall include main pressure gage and a branch pressure gage for each pneumatic device, installed inside.
7. Enclosures housing multiple instruments shall route tubing and wiring within enclosure in a raceway having a continuous removable cover.
8. Enclosures larger than 12 inches shall have a hinged full-size face cover.
9. Equip enclosure with lock and common key.

2.15 IDENTIFICATION

A. Equipment Warning Labels:
   1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
   2. Lettering size at least 14-point type with white lettering on red background.
   3. Warning label to read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
   4. Lettering to be enclosed in a white line border. Edge of label is to extend at least 0.25 inch beyond white border.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
   1. Verify compatibility with and suitability of substrates.
B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
D. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.
E. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.
B. Install products level, plumb, parallel, and perpendicular with building construction.
C. Support products, tubing, piping wiring, and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to <**Insert value**> force.
D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.
E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 078413 "Penetration Firestopping."
G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."
H. Welding Requirements:
   1. Restrict welding and burning to supports and bracing.
   2. No equipment is cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
   3. Welding, where approved, is to be by inert-gas electric arc process and is to be performed by qualified welders in accordance with applicable welding codes.
   4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.
I. Fastening Hardware:

1. Wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

J. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

3.03 INSTALLATION OF CONTROLLERS

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply.

C. Install controllers with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:
1. DDC system provider and DDC system manufacturer to determine quantity and location of network controllers to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Locate top of controller within 72 inches of finished floor.

F. Installation of Programmable Application Controllers:
1. DDC system provider and DDC system manufacturer to determine quantity and location of programmable application controllers to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Locate top of controller within 72 inches of finished floor, except where dedicated controllers are installed at terminal units.

G. Application-Specific Controllers:
1. DDC system provider and DDC system manufacturer to determine quantity and location of application-specific controllers to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.04 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade to provide a fully functioning DDC system. Work is to comply with NFPA 70 and other requirements indicated.

C. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.

D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

E. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems," Section 260533.16 "Boxes and Covers for Electrical Systems," and Section 260533.23 "Surface Raceways for Electrical Systems" for electrical power raceways and boxes.

3.05 INSTALLATION OF IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.

B. Warning Labels and Signs:

1. Permanently attach to equipment that can be automatically started by DDC control system.
2. Locate where highly visible near power service entry points.

3.06 INSTALLATION OF CONTROL WIRE, CABLE, AND RACEWAY

A. Comply with NECA 1.
B. Comply with TIA 568-C.1
C. Wiring Method: Install cables in raceways and cable trays. Conceal raceway and cables except in unfinished spaces.
   1. Install plenum cable in environmental air spaces, including plenum ceilings.
   2. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
D. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
E. Field Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
F. Conduit Installation:
   1. Install conduit expansion joints where conduit runs exceed 200 feet, and conduit crosses building expansion joints.
   2. Coordinate conduit routing with other trades to avoid conflicts with ducts, pipes and equipment and service clearance.
   3. Maintain at least 3-inch separation where conduits run axially above or below ducts and pipes.
   4. Limit above-grade conduit runs to 100 feet without pull or junction box.
   5. Do not install raceways or electrical items on any "explosion-relief" walls, or rotating equipment.
   6. Do not fasten conduits onto the bottom side of a metal deck roof.
   7. Flexible conduit is permitted only where flexibility and vibration control is required.
   8. Limit flexible conduit to 3 feet long.
   9. Conduit shall be continuous from outlet to outlet, from outlet to enclosures, pull and junction boxes, and shall be secured to boxes in such manner that each system shall be electrically continuous throughout.
   10. Direct bury conduits underground or install in concrete-encased duct bank where indicated.
      a. Use rigid, nonmetallic, Schedule 80 PVC.
      b. Provide a burial depth according to NFPA 70, but not less than 24 inches.
   11. Secure threaded conduit entering an instrument enclosure, cabinet, box, and trough, with a locknut on outside and inside, such that conduit system is electrically continuous throughout. Provide a metal bushing on inside with insulated throats. Locknuts shall be the type designed to bite into the metal or, on inside of enclosure, shall have a grounding wedge lug under locknut.
   12. Conduit box-type connectors for conduit entering enclosures shall have an insulated throat.
   13. Connect conduit entering enclosures in wet locations with box-type connectors or with watertight sealing locknuts or other fittings.
   14. Offset conduits where entering surface-mounted equipment.
   15. Seal conduit runs used by sealing fittings to prevent the circulation of air for the following:
      a. Conduit extending from interior to exterior of building.

b. Conduit extending into pressurized duct and equipment.
c. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.

G. Wire and Cable Installation:
1. Cables serving a common system may be grouped in a common raceway. Install control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
2. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.
3. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
5. UTP Cable Installation:
a. Comply with TIA 568-C.2.
b. Do not untwist UTP cables more than 1/2 inch from the point of termination, to maintain cable geometry.
6. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire shall have a unique tag.
7. Provide strain relief.
8. Terminate wiring in a junction box.
a. Clamp cable over jacket in junction box.
b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.
9. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
10. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
11. Keep runs short. Allow extra length for connecting to terminal boards. Do not bend flexible coaxial cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
12. Ground wire shall be copper and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.
13. Wire and cable shall be continuous from terminal to terminal without splices.
14. Use insulated spade lugs for wire and cable connection to screw terminals.
15. Use shielded cable to transmitters.
16. Use shielded cable to temperature sensors.
17. Perform continuity and meager testing on wire and cable after installation.
18. Do not install bruised, kinked, scored, deformed, or abraded wire and cable. Remove and discard wire and cable if damaged during installation, and replace it with new cable.
19. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

20. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
21. Protection from Electro-Magnetic Interference (EMI): Provide installation free of (EMI). As a minimum, comply with the following requirements:
    a. Comply with BICSI TDMM and TIA 569-C for separating unshielded cable from potential EMI sources, including electrical power lines and equipment.
    b. Separation between open 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.
        2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
        3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
    c. Separation between 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.
        2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
        3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
    d. Separation between 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.
        3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
    e. Separation between Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches.
    f. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.07 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.
B. Check instruments for proper location and accessibility.
C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
E. Control Damper Checkout:
    1. Verify that control dampers are installed correctly for flow direction.
    2. Verify that proper blade alignment, either parallel or opposed, has been provided.
    3. Verify that damper frame attachment is properly secured and sealed.
    4. Verify that damper actuator and linkage attachment are secure.
    5. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
    6. Verify that damper blade travel is unobstructed.
F. Control Valve Checkout:
    1. Verify that control valves are installed correctly for flow direction.
    2. Verify that valve body attachment is properly secured and sealed.
    3. Verify that valve actuator and linkage attachment are secure.
    4. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
    5. Verify that valve ball, disc, or plug travel is unobstructed.

6. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace valve if leaks persist.

G. Instrument Checkout:
1. Verify that instrument is correctly installed for location, orientation, direction, and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type, and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments, verify the following:
a. Sensing element type and proper material.
b. Length and insertion.

3.08 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION, AND TESTING

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
B. Provide written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
C. For each analog instrument, make three-point test of calibration for both linearity and accuracy.
D. Equipment and procedures used for calibration to comply with instrument manufacturer's written instructions.
E. Provide diagnostic and test equipment for calibration and adjustment.
1. Use field testing and diagnostic instruments and equipment with an accuracy at least twice the instrument accuracy of instrument to be calibrated. For example, test and calibrate an installed instrument with accuracy of 1 percent using field testing and diagnostic instrument with accuracy of 0.5 percent or better.
F. Calibrate each instrument in accordance with instruction manual supplied by instrument manufacturer.
G. If after calibration the indicated performance cannot be achieved, replace out-of-tolerance instruments.
H. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Controls Components," in the absence of specific requirements, and to supplement requirements indicated.
I. Analog Signals:
1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
J. Digital Signals:
1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

K. Control Dampers:
1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke pneumatic control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.
3. Check and document open and close cycle times for applications with cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

L. Control Valves:
1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke pneumatic control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.
3. Check and document open and close cycle times for applications with cycle time less than 30 seconds.
4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Meters: Check meters at zero, 50, and 100 percent of Project design values.

N. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

O. Switches: Calibrate switches to make or break contact at set points indicated.

P. Transmitters:
1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.09 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.
1. Verify voltage, phase, and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to backup power source.
6. If applicable, verify that power conditioning units are installed.

B. Verify that wire and cabling are properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.10 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:
1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify that operation is stable and accurate.

4. Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:
   a. Upper quarter of range.
   b. Lower quarter of range.
   c. At midpoint of range.
8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller, and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller, and at field instrument must match.
10. Prepare and submit report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.11 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from 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.

3.12 MAINTENANCE SERVICE

A. Beginning at Substantial Completion, verify that maintenance service includes 12 months' full maintenance by DDC system manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration, and adjusting as required for proper operation. Use only manufacturer's authorized replacement parts and supplies.

3.13 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

END OF SECTION

SECTION 230923.11
CONTROL VALVES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Ball-style control valves.
   2. Electric and electronic control valve actuators.

B. Related Requirements:
   1. Section 230923 "Direct Digital Control (DDC) System for HVAC" control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.03 DEFINITIONS

A. Cv: Valve coefficient.
B. DDC: Direct digital control.
C. EPT: Ethylene-propylene terpolymer rubber.
D. HNBR: Hydrogenated nitrile butadiene rubber.
E. NBR: Nitrile butadiene rubber.
F. PEEK: Polyether Ether Ketone rubber.
G. PTFE: Polytetrafluoroethylene.
H. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.
I. RTFE: Glass-fiber-reinforced PTFE.
J. TFM: A chemically modified PTFE.

1.04 ACTION SUBMITTALS

A. Product Data Submittals: For each product.
   1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
   3. Product description with complete technical data, performance curves, and product specification sheets.
   4. Installation, operation, and maintenance instructions, including factors affecting performance.

B. Delegated Design Submittals:
   1. Schedule and design calculations for control valves and actuators, including the following:
      a. Flow at project design and minimum flow conditions.
      b. Pressure differential drop across valve at project design flow condition.
      c. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.
      d. Design and minimum control valve coefficient with corresponding valve position.
      e. Maximum close-off pressure.
      f. Leakage flow at maximum system pressure differential.

g. Torque required at worst-case condition for sizing actuator.
h. Actuator selection indicating torque provided.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control valves.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

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. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
C. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.
D. Code Compliance: Comply with governing energy code.
E. Ground Fault: Properly ground products to prevent failing due to ground fault conditions.
F. Determine control valve sizes and flow coefficients by ISA 75.01.01.
G. Control valve characteristics and rangeability shall comply with ISA 75.11.01.
1. Control valve shutoff classifications shall be FCI 70-2, Class IV or better unless otherwise indicated.
2. Valve pattern, three-way or straight through, shall be as indicated on Drawings.
3. Modulating straight-through pattern control valves shall have equal percentage flow-throttling characteristics unless otherwise indicated.
4. Modulating three-way pattern water valves shall have linear flow-throttling characteristics. The total flow through the valve shall remain constant regardless of the valve's position.
5. Fail positions unless otherwise indicated:
a. Heating Hot Water: Open.
6. Globe-type control valves shall pass the design flow required with not more than 95 percent of stem lift unless otherwise indicated.
7. Rotary-type control valves, such as ball and butterfly valves, shall have Cv falling between 65 and 75 degrees of valve full open position and minimum valve Cv between 15 and 25 percent of open position.
8. Selection shall consider viscosity, flashing, and cavitation corrections.
9. Valves shall have stable operation throughout full range of operation, from design to minimum Cv.
10. In water systems, select modulating control valves at terminal equipment for a design Cv based on a pressure drop of 5 psig at design flow unless otherwise indicated.
11. Two-position control valves shall be line size unless otherwise indicated.
12. In water systems, use ball-style control valves for two-, and three-position control for valves NPS 2 and smaller and butterfly style for valves larger than NPS 2.

2.02 BALL-STYLE CONTROL VALVES

A. Ball Valves with Single Port and Characterized Disk:
1. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
2. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
3. Close-off Pressure: 200 psig.
4. Process Temperature Range: Zero to 212 deg F.
5. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
6. End Connections: Threaded (NPT) ends.

7. Ball: 300 series stainless steel.
8. Stem and Stem Extension:
   a. Material to match ball.
   b. Blowout-proof design.
   c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.
9. Ball Seats: Reinforced PTFE.
10. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
11. Flow Characteristic: Equal percentage.

2.03 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

A. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.
B. Position indicator and graduated scale on each actuator.
C. Type: Motor operated, with or without gears, electric and electronic.
D. Voltage: Voltage selection delegated to professional designing control system.
E. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
F. Function properly within a range of 85 to 120 percent of nameplate voltage.
G. Construction:
   1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
   2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
   3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
H. Field Adjustment:
   1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
   2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.
I. Two-Position Actuators: Single direction, spring return or reversing type.
J. Modulating Actuators:
   1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
   2. Control Input Signal:
      a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
      b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for 4- to 20-mA signals.
      c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.
      d. Programmable Multi-Function:

1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

K. Integral Overload Protection:
1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

L. Valve Attachment:
1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

M. Temperature and Humidity:
1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

N. Enclosure:
1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with heater and control where required by application.

O. Stroke Time:
1. Operate valve from fully closed to fully open within 60 seconds.
2. Operate valve from fully open to fully closed within 60 seconds.
3. Move valve to failed position within 30 seconds.
4. Select operating speed to be compatible with equipment and system operation.

P. Sound:
1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for valves installed in piping to verify actual locations of piping connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.02 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support control valves and actuators, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and

sway or a break in attachment when subjected to a seismic event, wind, or others forces common to the application.

D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Seal penetrations made in fire-rated and acoustically rated assemblies.

F. Fastening Hardware:
   1. Wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
   3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

H. Corrosive Environments:
   1. Use products that are suitable for environment to which they will be subjected.
   2. Use Type 316 stainless steel tubing and fittings when in contact with a corrosive environment.
   3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
   4. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.03 CONTROL VALVES

A. Install pipe reducers for control valves smaller than line size. Position reducers as close to control valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation.

C. Valve Orientation:
   1. Where possible, install ball valves that are installed in horizontal piping, with stems upright and not more than 15 degrees off of vertical, not inverted.
   2. Install valves in a position to allow full stem movement.
   3. Where possible, install butterfly valves that are installed in horizontal piping, with stems in horizontal position and with low point of disc opening with direction of flow.

D. Clearance:
   1. Locate valves for easy access, and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
   2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

E. Threaded Valves:
   1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
   2. Align threads at point of assembly.
   3. Apply thread compound to external pipe threads, except where dry seal threading is specified.

4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

3.04 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Use same designation at each end for each piece of wire, cable, and tubing for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.05 ELECTRICAL CONNECTIONS

A. Install electrical power to field-mounted control devices requiring electrical power.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260523 "Control-Voltage Electrical Power Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

3.06 CONTROL CONNECTIONS

A. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

B. Install control signal wiring to field-mounted control devices.

C. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.07 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

3.08 STARTUP

A. Control Valve Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check valves for proper location and accessibility.
3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Verify that control valves are installed correctly for flow direction.
5. Verify that valve body attachment is properly secured and sealed.
6. Verify that valve actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that valve ball, disc, and plug travel are unobstructed.
9. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.09 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

C. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION

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SECTION 230923.12
CONTROL DAMPERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Positive seal control dampers for bubble-tight isolation using dish blade with welded frame and flange mounting.
   2. Rectangular control dampers.
   3. Round control dampers.
   4. General control-damper actuator requirements.
   5. Electric and electronic control-damper actuators.

B. Related Requirements:
   1. Section 230923 "Direct Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.03 DEFINITIONS

A. DDC: Direct digital control.

B. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

C. Thermal Efficiency Ratio (E): Comparison of a tested damper's thermal performance against a v-groove blade reference damper. A damper with the same thermal efficiency as the reference damper would have an E value of 0 percent, while a damper that is 4 times as efficient would have an E value of 200 percent.

1.04 ACTION SUBMITTALS

A. Product Data Submittals: For each type of product, including the following:
   1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
   3. Product description with complete technical data, performance curves, and product specification sheets.
   4. Installation instructions, including factors affecting performance.

B. Shop Drawings:
   1. Include plans, elevations, sections, and mounting details.
   2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control dampers.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

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. ASHRAE 62.1 Compliance: Applicable outdoor ventilation requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. Code Compliance: Comply with governing energy code.

E. Ground Fault: Properly ground products to prevent failing due to ground fault conditions.

F. Backup Power Source: Serve control-damper actuators from a backup power source where associated with systems and equipment served by a backup power source.

G. Environmental Conditions: For actuators not available with integral enclosures complying with requirements indicated, house in protective secondary enclosures complying with requirements.

H. Selection Criteria:

1. Fail positions unless otherwise indicated:
   a. Outdoor Air: Close.
   b. Exhaust Air: Last position.
2. Two-position dampers shall be full size of duct or equipment connection unless otherwise indicated.

2.02 RECTANGULAR CONTROL DAMPERS

A. General Requirements:

1. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed blade configuration.
2. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
3. Damper actuator shall be factory installed by damper manufacturer as integral part of damper assembly. Coordinate actuator location and mounting requirements with damper manufacturer.

B. Rectangular Dampers with Steel Flat Blades:

1. Performance:
   a. Leakage: Leakage shall not exceed 4.8 cfm/sq. ft. against 1-in. wg differential static pressure.
   b. Pressure Drop: 0.1-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
   c. Velocity: Up to 1500 fpm.
   d. Temperature: Minus 25 to plus 180 deg F.
   e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, not to exceed 4-in. wg.
   f. Damper shall have AMCA seal for both air leakage and air performance.
2. Construction:
   a. Frame:
      1) Material: Galvanized or stainless steel, 0.06 inch thick.
      2) Hat-shaped channel with integral flanges.
      3) Width not less than 5 inches.
   b. Blades:
      1) Flat blades with multiple grooves positioned axially for reinforcement.

2) Parallel or opposed blade configuration as required by application.
3) Material: Galvanized or stainless steel, 0.06 inch thick.
4) Width not to exceed 6 inches.
5) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals:
1) Blades: Replaceable, mechanically attached, PVC-coated polyester.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch-diameter plated or stainless steel, mechanically attached to blades.

e. Bearings:
1) Molded-synthetic sleeve, mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:
1) Concealed in frame.
2) Constructed of plated or stainless steel.
3) Hardware: Stainless steel.

2.03 ROUND CONTROL DAMPERS

A. Round Dampers, Sleeve Type:

1. Performance:
a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
b. Pressure Drop: 0.02-in. wg at 1500 fpm across a 12-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Minus 25 to plus 200 deg F.
e. Pressure Rating: 8-in. wg for sizes through 12 inches, 6-in. wg for larger sizes.

2. Construction:
a. Frame:
1) Material: Galvanized or stainless steel, 0.04 in thick.
2) Outward rolled stiffener beads positioned approximately 1 inch inboard of each end.
3) Sleeve-type connection for mating to adjacent ductwork.
4) Size Range: 4 to 24 inches.
5) Length not less than 7 inches.
6) Provide 2-inch sheet metal stand-off for mounting actuator.

b. Blade: Double-thickness circular flat blades sandwiched together and constructed of galvanized or stainless steel.
c. Blade Seal: Polyethylene foam seal sandwiched between two sides of blades and fully encompassing blade edge.
d. Axle: 0.5-inch-diameter plated or stainless steel, mechanically attached to blade.
e. Bearings: Stainless-steel sleeve pressed into frame.

B. Round Dampers, Flanged Type:

1. Performance:
a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
b. Pressure Drop: 0.03-in. wg at 1500 fpm across a 12-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Minus 25 to plus 250 deg F.

e. Pressure Rating: 8-in. wg for sizes through 36 inches in diameter, 6-in. wg for larger sizes.

2. Construction:

a. Frame:

1) Size Range: 4 to 60 inches.

2) Material: Galvanized or stainless steel.

a) Sizes through 24 Inches in Diameter: 0.15 inch thick.

b) Sizes 26 through 48 Inches in Diameter: 0.25 inch thick.

c) Larger Sizes: 0.31 inch thick.

3) Flanges:

a) Outward rolled with bolt holes on each end of frame for mating to adjacent ductwork.

b) Face: Not less than 1.25 inch for damper sizes through 12 inches in diameter, 1.5 inch for damper sizes 14 through 24 inches in diameter, and 2 inches for larger sizes.

4) Length (Flange Face to Face): Not less than 8 inches.

5) Provide 3-inch sheet metal stand-off for mounting actuator.

b. Blade: Reinforced circular flat blade constructed of galvanized or stainless steel.

1) Sizes through 24 Inches: 0.15 inch thick.

2) Sizes 26 through 48 Inches: 0.19 inch thick.

3) Larger Sizes: 0.25 inch thick.

c. Blade Stop: Full circumference, located in airstream, minimum 0.5 by 0.25 inch galvanized- or stainless- steel bar.

d. Blade Seal: Neoprene, mechanically attached to blade and fully encompassing blade edge.

e. Axle: Plated or stainless steel, mechanically attached to blade.

1) Sizes through 14 Inches: 0.5 inch in diameter.

2) Sizes 16 through 42 Inches: 0.75 inch in diameter.

3) Larger Sizes: 1 inch in diameter.

f. Bearings: Stainless-steel sleeve pressed into frame.

2.04 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail in desired position in the event of a power failure.

I. Actuator Fail Positions: As indicated below.

1. Exhaust Air: Last position.

2. Outdoor Air: Close.

2.05 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Voltage:
   1. 120 V.
   2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
   3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

C. Construction:
   1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
   2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
   3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

D. Field Adjustment:
   1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
   2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

E. Two-Position Actuators: Single direction, spring return or reversing type.

F. Position Feedback:
   1. Where indicated, equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.

G. Fail-Safe:
   1. Where indicated, provide actuator to fail to an end position.
   2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
   3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

H. Integral Overload Protection:
   1. Provide against overload throughout the entire operating range in both directions.
   2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

I. Damper Attachment:
   1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
   2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
   3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

J. Temperature and Humidity:
   1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
   2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

K. Enclosure:
1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

L. Stroke Time:
1. Operate damper from fully closed to fully open within 15 seconds.
2. Operate damper from fully open to fully closed within 15 seconds.
3. Move damper to failed position within 15 seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

M. Sound:
1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.02 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.

C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Seal penetrations made in fire-rated and acoustically rated assemblies.

E. Fastening Hardware:
1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

G. Corrosive Environments:
1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.

4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.03 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 15 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:
1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

C. Service Access:
1. Dampers and actuators shall be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.04 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with damper identification on damper.

3.05 ELECTRICAL CONNECTIONS

A. Install electrical power to field-mounted control devices requiring electrical power.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260523 "Control-Voltage Electrical Power Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

E. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

F. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

G. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

3.06 CONTROL CONNECTIONS

A. Install control signal wiring to field-mounted control devices.

B. Connect control signal wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

C. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.07 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

3.08 STARTUP

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
4. Verify that control dampers are installed correctly for flow direction.
5. Verify that proper blade alignment, either parallel or opposed, has been provided.
6. Verify that damper frame attachment is properly secured and sealed.
7. Verify that damper actuator and linkage attachment are secure.
8. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
9. Verify that damper blade travel is unobstructed.

3.09 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION

SECTION 231123
FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Pipes, tubes, and fittings.
   2. Piping and tubing joining materials.
   3. Manual gas shutoff valves.

1.03 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, 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.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Piping specialties.
   2. Corrugated, stainless-steel tubing with associated components.
   3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
   4. Pressure regulators. Indicate pressure ratings and capacities.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.06 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

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.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. 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.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

1.08 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and

then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.09 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressure within Buildings: 0.5 psig or less.

2.02 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
3. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   a. Material Group: 1.1.
   b. End Connections: Threaded or butt welding to match pipe.
   c. Lapped Face: Not permitted underground.
   d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
   e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

2.03 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

2.04 MANUAL GAS SHUTOFF VALVES

A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig.
2. Threaded Ends: Comply with ASME B1.20.1.
3. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
4. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

B. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Service Mark: Initials "WOG" shall be permanently marked on valve body.

2.05 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.

2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Line Pressure Regulators: Comply with ANSI Z21.80.
1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
3. Diaphragm Plate: Zinc-plated steel.
4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
5. Orifice: Aluminum; interchangeable.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
9. Overpressure Protection Device: Factory mounted on pressure regulator.
10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
11. Maximum Inlet Pressure: 5 psig.

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.
1. Body and Diaphragm Case: Die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
3. Diaphragm Plate: Zinc-plated steel.
4. Seat Disc: Nitrile rubber.
5. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
6. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
7. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
8. Maximum Inlet Pressure: 5 psig.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

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

3.02 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with the International Fuel Gas Code requirements for prevention of accidental ignition.

3.03 INDOOR PIPING INSTALLATION

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

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

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
E. 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.
F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
G. Locate valves for easy access.
H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
I. Install piping free of sags and bends.
J. Install fittings for changes in direction and branch connections.
K. Verify final equipment locations for roughing-in.
L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
    1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
    1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
    2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
    3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
    4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
        a. Exception: Tubing passing through partitions or walls does not require striker barriers.
    5. Prohibited Locations:
        a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.

b. Do not install natural-gas piping in solid walls or partitions.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.

S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator.

V. Install pressure gage downstream from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "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 Section 230517 "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 Section 230518 "Escutcheons for HVAC Piping."

3.04 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance.

B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.05 PIPING 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. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. 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. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

3.06 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

3.07 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
C. Install piping adjacent to appliances to allow service and maintenance of appliances.
D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.08 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

3.09 PAINTING

A. Paint exposed, exterior metal piping, with field-applied protective coating.
   1. Alkyd System: MPI EXT 5.1D.
      a. Prime Coat: Alkyd anticorrosive metal primer.
      b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
      c. Topcoat: Exterior alkyd enamel (semigloss).
      d. Color: Gray.
B. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.
B. Tests and Inspections:
   1. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.
C. Natural-gas piping will be considered defective if it does not pass tests and inspections.
D. Prepare test and inspection reports.

3.11 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

A. Aboveground, branch piping NPS 1 and smaller shall be the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.
B. Aboveground, distribution piping shall be one of the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.

END OF SECTION

SECTION 232113
HYDRONIC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Copper tube and fittings.
   2. Piping joining materials.
   3. Transition fittings.
   4. Dielectric fittings.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Pipe and tube.
   2. Fittings.
   3. Joining materials.
   4. Transition fittings.

1.03 INFORMATIONAL SUBMITTALS

A. Qualification Data: For installer.

B. Pipe Welding: Qualify procedures and operators in accordance with ASME Boiler and Pressure Vessel Code: Section IX.
   1. Comply with ASME B31.9 for materials, products, and installation.
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.04 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.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation are to be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
   1. Hot-Water Heating Piping: 100 psig at 180 deg F.
   2. Pressure-Relief-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.02 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. DWV Copper Tubing: ASTM B 306, Type DWV.

C. Copper or Bronze Pressure-Seal Fittings:
   1. Housing: Copper.
   2. O-Rings and Pipe Stops: EPDM.
   3. Tools: Manufacturer's special tools.
   4. Minimum 200-psig working-pressure rating at 250 deg F.

D. Wrought-Copper Unions: ASME B16.

2.03 PIPING JOINING MATERIALS

A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

2.04 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 Unions:
   1. Description:
      a. Standard: ASSE 1079.
      b. Pressure Rating: 150 psig.
      c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
   1. Description:
      a. Standard: ASSE 1079.
      b. Factory-fabricated, bolted, companion-flange assembly.
      c. Pressure Rating: 150 psig.
      d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:
   1. Description:
      a. Nonconducting materials for field assembly of companion flanges.
      b. Pressure Rating: 150 psig.
      c. Gasket: Neoprene or phenolic.
      d. Bolt Sleeves: Phenolic or polyethylene.
      e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:
   1. Description:
      a. Standard: IAPMO PS 66.
      b. Electroplated steel nipple, complying with ASTM F 1545.
      c. Pressure Rating: 300 psig at 225 deg F.
      d. End Connections: Male threaded or grooved.
      e. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and pressure-seal joints. Soldered joints may be installed.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and pressure-seal joints.

C. Condensate-Drain Piping: Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

D. 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.

3.02 INSTALLATION OF PIPING

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate

friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved prior to installation.

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 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

N. Install valves according to the following:
   1. Section 230523.12 "Ball Valves for HVAC Piping."
   2. Section 230523.14 "Check Valves for HVAC Piping."

O. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

P. Install shutoff valve immediately upstream of each dielectric fitting.

Q. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.03 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. 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.

E. 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. PVC Nonpressure Piping: Join according to ASTM D 2855.

F. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.04 INSTALLATION OF DIELECTRIC FITTINGS

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 unions.

3.05 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

B. Install hangers for copper tubing and piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Install hangers for plastic piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping within 12 inches of each fitting and coupling.

E. Support vertical runs of copper tubing and piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.06 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections are to be the same as or larger than equipment connections.

B. Install 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, only one bypass is required.

D. Install ports for pressure gauges and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gauges for HVAC Piping."

3.07 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 230553 "Identification for HVAC Piping and Equipment."

3.08 SYSTEM STARTUP

A. 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.

3.09 FIELD QUALITY CONTROL

A. Prepare hydronic piping in accordance with ASME B31.9 and as follows:
1. Leave joints, 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; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure is to be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install pressure-relief 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 that is not less than 1.5 times the system's working pressure. Test pressure is not to 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.
5. 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.
6. Prepare written report of testing.

END OF SECTION

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SECTION 232116
HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Hydronic specialty valves.
   2. Air vents.
   3. Expansion tanks and fittings.
   4. Strainers.
   5. Flexible connectors.

B. Related Requirements:
   1. Section 230523.12 "Ball Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
   2. Section 230523.14 "Check Valves for HVAC Piping" for specification and installation requirements for check valves common to most piping systems.
   3. Section 230923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product:
   1. Include construction details and material descriptions for hydronic piping specialties.
   2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
   3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.04 CLOSEOUT SUBMITTALS

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

1.05 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.

1.06 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators in accordance with ASME BPVC, Section IX.

B. Pressure-relief and safety-relief valves and pressure vessels bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME BPVC, Section VIII, Division 1.

PART 2 - PRODUCTS

2.01 HYDRONIC SPECIALTY VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:
   1. Body: Bronze, ball or plug type with calibrated orifice or venturi.
   2. Ball: Brass or stainless steel.
   3. Plug: Resin.
   4. Seat: PTFE.
   5. End Connections: Threaded or socket.
   6. Pressure Gage Connections: Integral seals for portable differential pressure meter.
   7. Handle Style: Lever, with memory stop to retain set position.

8. CWP Rating: Minimum 125 psig.
9. Maximum Operating Temperature: 250 deg F.

B. Automatic Flow-Control Valves:
1. Body: Brass or ferrous metal.
2. Flow Control Assembly, provide either of the following:
a. Piston and Spring Assembly: Corrosion resistant, tamper proof, self-cleaning, and removable.
b. Elastomeric Diaphragm and Polyphenylsulfone Orifice Plate: Operating ranges within 2- to 80-psig differential pressure.
3. Combination Assemblies: Include bronze or brass-alloy ball valve.
4. Identification Tag: Marked with zone identification, valve number, and flow rate.
5. Size: Same as pipe in which installed.
6. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
7. Minimum CWP Rating: 175 psig.
8. Maximum Operating Temperature: 200 deg F.

2.02 AIR VENTS

A. Manual Air Vents:
1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

B. Automatic Air Vents:
1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 240 deg F.

2.03 EXPANSION TANKS AND FITTINGS

A. Bladder-Type ASME Expansion Tanks:
1. Tank: Welded steel, rated for 125 psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled in accordance with ASME BPVC, Section VIII, Division 1.
2. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

2.04 STRAINERS

A. Y-Pattern Strainers:
1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless steel, 20-mesh strainer, or perforated stainless steel basket.

4. CWP Rating: 125 psig.

2.05 FLEXIBLE CONNECTORS

A. Stainless Steel Bellows, Flexible Connectors:
   1. Body: Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
   2. End Connections: Threaded or flanged to match equipment connected.
   3. Performance: Capable of 3/4-inch misalignment.
   4. CWP Rating: 150 psig.
   5. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine all piping specialties 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. Examine threads on all devices for form and cleanliness.

C. 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.

D. Do not attempt to repair defective piping specialties; replace with new devices. Remove defective piping specialties from site.

3.02 INSTALLATION OF VALVES

A. Install calibrated-orifice balancing valve at each branch connection to return main.

B. Install calibrated-orifice, balancing valve in the return pipe of each heating or cooling terminal.

C. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

D. Install pressure-relief and safety-relief valves at hot-water generators and elsewhere as required by ASME BPVC. Pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME BPVC, Section VIII, Division 1, for installation requirements.

3.03 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only.
   1. Provide air outlet drain line full size of air outlet to floor drain or to other point indicated on Drawings.

C. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

D. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve full size of separator outlet; extend full size to nearest floor drain.

E. Install piping from air separator or air purger to expansion tank with a 2 percent upward slope toward tank to avoid air entrapment.

F. Vent and purge air from hydronic system and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION

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SECTION 232123
HYDRONIC PUMPS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Close-coupled, in-line centrifugal pumps.

1.03 DEFINITIONS

A. HI: Hydraulic Institute.
B. NBR: Nitrile rubber or Buna-N.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of pump.
   1. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
   2. Indicate pump's operating point on curves.
B. Shop Drawings: For each pump.
   1. Show pump layout and connections.
   2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
   3. Include diagrams for power, signal, and control wiring.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

1.06 CLOSEOUT SUBMITTALS

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

1.07 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. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

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.

2.02 SOURCE LIMITATION

A. Provide all hydronic pumps from the same manufacturer.

2.03 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers: Grundfos, ITT Corporation, Bell & Gossett, Armstrong Pumps, Inc., or TACO Comfort Solutions, Inc.
B. 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.
C. Pump Construction:
   1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet and threaded union-end connections.

2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft Sleeve: Bronze.
4. Pump Stub Shaft: Type 304 or Type 316 stainless steel.
5. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR rubber bellows and gasket. Include water slinger on shaft between motor and seal.
6. Seal Flushing: Flush, cool, and lubricate pump seal by directing pump discharge water to flow over the seal.

D. Shaft Coupling: Rigid, axially-split spacer coupling to allow service of pump seal without disturbing pump or motor.

E. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
1. Enclosure : Open, dripproof.
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 electrical Sections.
4. Single-speed motor.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine equipment mounting and support locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

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

3.02 PUMP INSTALLATION

A. Comply with HI 1.4 and HI 2.4.

B. Install pumps to provide access for periodic maintenance including removing 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. Equipment Mounting:
1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and spring hangers of size required to support weight of in-line pumps.
1. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.03 PIPING CONNECTIONS

A. Where installing piping adjacent to pump, allow space for service and maintenance.

B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

D. Install isolation valve on suction and discharge side of pumps.

E. Install flexible connectors on suction and discharge sides between pump casing and valves.

F. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.

3.04 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

3.05 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.06 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping. Use startup strainer for initial startup.
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 correct direction.
5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.07 DEMONSTRATION

A. Train Owner’s maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION

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SECTION 232300
REFRIGERANT PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Copper tube and fittings.
   2. Steel pipe and fittings.
   3. Valves and specialties.
   4. Refrigerants.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of valve, refrigerant piping, and piping specialty.

1.03 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding, Brazing, and Fusing Qualifications."

1.04 DELIVERY, STORAGE, AND HANDLING

A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Comply with ASHRAE 15.
B. Comply with ASME B31.5.
C. Test Pressure shall be as required to assure piping exceeds the maximum system internal pressure as determined by the equipment manufacturer based and on the refrigerant used in the system.
   1. Test to included: Suction, Liquid, and Hot-Gas tubing and piping as applicable to the system.

2.02 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. Brazing Filler Metals: AWS A5.8M/A5.8.

PART 3 - EXECUTION

3.01 PIPING APPLICATION SCHEDULES

A. Suction, Hot-Gas, and Liquid Tubing for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
B. Suction, Hot-Gas, and Liquid Tubing for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

3.02 INSTALLATION OF PIPING, GENERAL

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 in accordance with 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 Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" 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 Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
N. 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.
O. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
P. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
Q. Identify refrigerant piping and valves in accordance with Section 230553 "Identification for HVAC Piping and Equipment."
R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.03 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. Brazed Joints: Construct joints in accordance with AWS BRH, "Brazing Handbook," Ch. 35, "Pipe and Tubing."
    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.

3.04 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

B. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal runs less than 20 ft. long.
   2. Roller hangers and spring hangers for individual horizontal runs 20 ft. or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 ft. or longer, supported on a trapeze.
   4. Spring hangers to support vertical runs.
   5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping within 12 inches of each fitting.

E. Support vertical runs of copper tubing to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.05 FIELD QUALITY CONTROL

A. 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 "Performance Requirements" Article.
      a. Fill system with nitrogen to the required test pressure.
      b. System must maintain test pressure at the manifold gauge 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.

B. Prepare test and inspection reports.

3.06 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. 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.
   4. Charge system with a new filter-dryer core in charging line.

3.07 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 controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
   1. Verify that compressor oil level is correct.

2. Open compressor suction and discharge valves.
3. Open refrigerant valves but not bypass valves that are used for other purposes.
4. 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

SECTION 233113
METAL DUCTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Single-wall rectangular ducts and fittings.
   2. Single-wall round ducts and fittings.
   3. Sheet metal materials.
   4. Sealants and gaskets.
   5. Hangers and supports.

B. Related Requirements:
   1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
   2. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
   3. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
   1. Sealants and gaskets.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Airstream Surfaces: Surfaces in contact with airstream comply with requirements in ASHRAE 62.1.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

E. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.02 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
   1. Construct ducts of galvanized sheet steel unless otherwise indicated.
   2. For ducts exposed to weather, construct of Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation.

B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.

2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.03 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.

B. Source Limitations: Obtain single-wall round ducts and fittings from single manufacturer.

C. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.04 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials are to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G60.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

D. Tie Rods: Galvanized steel, 1/4-inch-minimum diameter for lengths 36 inches or less; 3/8-inch-minimum diameter for lengths longer than 36 inches.

2.05 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets are to be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:
1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 4 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:
1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
9. Service: Indoor or outdoor.
10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C920.
1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.

4. Class: 25.
5. Use: O.

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.06 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-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, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

E. Steel Cables for Stainless Steel Ducts: Stainless steel complying with ASTM A492.

F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

PART 3 - EXECUTION

3.01 DUCT INSTALLATION

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 prior to installation.

B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. 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.

J. Install fire**,** combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Elbows: Use long-radius elbows wherever they fit.
   1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
   2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

N. Branch Connections: Use lateral or conical branch connections.

3.02 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. Do not use two-part tape sealing system.

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 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.

3.03 DUCTWORK EXPOSED TO WEATHER

A. All external joints are to have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.

B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.

C. Single Wall:
   1. Ductwork is to be galvanized steel.
      a. If duct outer surface is uninsulated, protect outer surface with suitable paint. Paint materials and application requirements are specified in Section 099113 "Exterior Painting."
   2. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section 230713 "Duct Insulation."

3.04 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
   1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   2. Outdoor, Supply-Air Ducts: Seal Class A.
   3. Outdoor, Exhaust Ducts: Seal Class C.
   4. Outdoor, Return-Air Ducts: Seal Class C.
   5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
   6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
   7. Unconditioned Space, Exhaust Ducts: Seal Class C.
   8. Unconditioned Space, Return-Air Ducts: Seal Class B.

9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.05 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
   5. Do not use powder-actuated concrete fasteners for seismic restraints. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.06 DUCTWORK CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.07 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
   1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
   2. Test the following systems:

a. Supply Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.

3.09 STARTUP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
   1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.

B. Supply Ducts:
   1. Ducts Connected to Terminal Units:
      a. Pressure Class: Positive 1-inch wg.
   2. Ducts Connected to Constant-Volume Air-Handling Units:
      a. Pressure Class: Positive 2-inch wg.
      b. Minimum SMACNA Seal Class: A.
   3. Ducts Connected to Variable-Air-Volume Air-Handling Units:
      a. Pressure Class: Positive 3-inch wg.
      b. Minimum SMACNA Seal Class: A.

C. Return Ducts:
   1. Ducts Connected to Terminal Units:
      a. Pressure Class: Positive or negative 1-inch wg.
      b. Minimum SMACNA Seal Class: C.
   2. Ducts Connected to Air-Handling Units
      a. Pressure Class: Positive or negative 2-inch wg.
      b. Minimum SMACNA Seal Class: A.

D. Exhaust Ducts:
   1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
      a. Pressure Class: Negative 2-inch wg.
      b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.

E. Intermediate Reinforcement:
   1. Galvanized-Steel Ducts: Galvanized steel.

F. Elbow Configuration:
   1. Rectangular Duct - Requirements for Different Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
      a. Velocity 1000 fpm or Lower:
         1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
         2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm:
   1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
   2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
   3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
c. Velocity 1500 fpm or Higher:
   1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct - Requirements for All Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
      1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      4) Radius-to Diameter Ratio: 1.5.
   b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14 Inches and Larger in Diameter: Welded.

G. Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Conical spin in.
2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
   a. Velocity 1000 fpm or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm: Conical tap.
   c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION

SECTION 233300
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Manual volume dampers.
   2. Control dampers.
   3. Fire dampers.
   4. Flange connectors.
   5. Turning vanes.
   6. Duct-mounted access doors.
   7. Flexible connectors.
   8. Duct accessory hardware.

B. Related Requirements:
   1. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 90A and NFPA 90B.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.02 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
   1. Performance:
      a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.
   2. Construction:
      a. Linkage out of airstream.
      b. Suitable for horizontal or vertical airflow applications.
   3. Frames:
      a. Hat-shaped, 16-gauge-thick, galvanized sheet steel.
      b. Mitered and welded corners.
      c. Flanges for attaching to walls and flangeless frames for installing in ducts.
   4. Blades:
      a. Multiple or single blade.
      b. Parallel- or opposed-blade design.
      c. Stiffen damper blades for stability.
      d. Galvanized steel; 16 gauge thick.
   5. Blade Axles: Galvanized steel.
   6. Bearings:

a. Oil-impregnated bronze.
b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.

7. Tie Bars and Brackets: Galvanized steel.
8. Locking device to hold damper blades in a fixed position without vibration.

B. Jackshaft:
1. Size: 0.5-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:
1. Zinc-plated, die-cast core with dial and handle, made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.03 CONTROL DAMPERS

A. General Requirements:
1. Unless otherwise indicated, use parallel-blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.
2. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.

B. Performance:
1. Leakage:
a. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
2. Pressure Drop: 0.05 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, Figure 5.3.
3. Velocity: Up to 3000 fpm.
4. Temperature: Minus 25 to plus 180 deg F.
5. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

C. Construction:
1. Linkage out of airstream.
2. Suitable for horizontal or vertical airflow applications.
3. Frames:
a. Hat, U, or angle shaped.
b. 16-gauge-thick, galvanized sheet steel.
c. Mitered and welded corners.
d. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
a. Multiple blade with maximum blade width of 8 inches.
b. Opposed-blade design.
c. Galvanized steel.
d. 16-gauge-thick single skin.
5. Blade Edging Seals:
a. Replaceable PVC.
b. Inflatable seal blade edging, or replaceable rubber seals.

6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch diameter; galvanized steel.
8. Blade-Linkage Hardware: Zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of air stream.
9. Bearings:
   a. Oil-impregnated bronze.
   b. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.

D. Damper Actuator - Electric:
1. Electric - 120 V ac.
2. UL 873, plenum rated.
3. Two position with fail-safe spring return.
   a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
   b. Minimum 90-degree drive rotation.
4. Clockwise or counterclockwise drive rotation as required for application.
5. Environmental Operating Range:
   a. Temperature: Minus 40 to plus 130 deg F.
   b. Humidity: 5 to 95 percent relative humidity noncondensing.
6. Environmental enclosure: NEMA 2.
7. Actuator to be factory mounted and provided with a single-point wiring connection.

E. Controllers, Electrical Devices, and Wiring:
1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Electrical Connection: 115 V, single phase, 60 Hz.

2.04 FIRE DAMPERS

A. Type: dynamic; rated and labeled in accordance with UL 555 by an NRTL.
B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000 fpm velocity.
C. Fire Rating: 1-1/2 hours.
D. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.
E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel; gauge in accordance with UL listing.
F. Mounting Orientation: Vertical or horizontal as indicated.
G. Blades: Roll-formed galvanized sheet steel, interlocking full-length steel blade connectors. Material gauge is to be in accordance with UL listing.
H. Horizontal Dampers: Include blade lock and stainless steel closure spring.
I. Heat-Responsive Device:
1. Replaceable, 165 deg F rated, fusible links.

2.05 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.
B. Material: Galvanized steel.
C. Gauge and Shape: Match connecting ductwork.

2.06 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
   1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

D. Vane Construction:
   1. Single wall.
   2. Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.07 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."
   1. Door:
      a. Double wall, rectangular.
      b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
      c. 24-gauge-thick galvanized steel door panel.
      d. Vision panel.
      e. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
      f. Fabricate doors airtight and suitable for duct pressure class.
   2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
      a. 24-gauge-thick galvanized steel or 0.032-inch-thick aluminum frame.
   3. Number of Hinges and Locks:
      a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
      b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
      c. Access Doors up to 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.
      d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.

2.08 FLEXIBLE CONNECTORS

A. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Materials: Flame-retardant or noncombustible fabrics.

D. Coatings and Adhesives: Comply with UL 181, Class 1.

E. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.

F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
   1. Minimum Weight: 26 oz./sq. yd..

2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

G. 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..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

H. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular 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. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.09 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

3.01 INSTALLATION

A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.

B. Install 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 at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.

E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.
H. Install fire and smoke dampers in accordance with UL listing.
I. Duct security bars:
J. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
    1. On both sides of duct coils.
    2. Upstream and downstream from duct filters.
    3. At outdoor-air intakes and mixed-air plenums.
    4. At drain pans and seals.
    5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
    6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
    7. At each change in direction and at maximum 50-ft. spacing.
    8. Upstream and downstream from turning vanes.
    9. Control devices requiring inspection.
    10. Elsewhere as indicated.
K. Install access doors with swing against duct static pressure.
L. Access Door Sizes:
    1. One-Hand or Inspection Access: 8 by 5 inches.
    2. Two-Hand Access: 12 by 6 inches.
    3. Head and Hand Access: 18 by 10 inches.
    4. Head and Shoulders Access: 21 by 14 inches.
    5. Body Access: 25 by 14 inches.
    6. Body plus Ladder Access: 25 by 17 inches.
M. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
N. Install flexible connectors to connect ducts to equipment.
O. Install duct test holes where required for testing and balancing purposes.
P. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.02 FIELD QUALITY CONTROL

A. Tests and Inspections:
    1. Operate dampers to verify full range of movement.
    2. Inspect locations of access doors, and verify that size and location of access doors are adequate to perform required operation.
    3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.
    4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
    5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION

SECTION 233346
FLEXIBLE DUCTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Non-insulated flexible ducts.
   2. Insulated flexible ducts.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
B. Shop Drawings: For flexible ducts.
   1. Include plans showing locations and mounting and attachment details.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved.

PART 2 - PRODUCTS

2.01 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."
D. Comply with ASTM E96/E96M, "Test Methods for Water Vapor Transmission of Materials."

2.02 INSULATED FLEXIBLE DUCTS

A. Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   2. Maximum Air Velocity: 4000 fpm.
   3. Temperature Range: Minus 20 to plus 210 deg F.
   4. Insulation R-Value: Comply with ASHRAE/IES 90.1.

2.03 FLEXIBLE DUCT CONNECTORS

A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.
B. Non-Clamp Connectors: Adhesive plus sheet metal screws.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install flexible ducts 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. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.
C. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
D. Connect diffusers or light troffer boots to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

E. Connect flexible ducts to metal ducts with draw bands.
F. Install duct test holes where required for testing and balancing purposes.
G. Installation:
   1. Install ducts fully extended.
   2. Do not bend ducts across sharp corners.
   3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
   4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
   5. Install flexible ducts in a direct line, without sags, twists, or turns.
H. Supporting Flexible Ducts:
   1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
   2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
   3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
   4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

END OF SECTION

SECTION 233400
HVAC FANS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Fans, tubeaxial.
2. Fans, vaneaxial.
3. Fans, mixed flow.
4. Fans, centrifugal - backward-inclined blades.
5. Fans, centrifugal - forward-curved blades.
6. Fans, centrifugal, inline - square.
7. Fans, centrifugal, inline - tubular.
8. Fans, plenum.
9. Fans, plug.
10. Fans, utility set.
11. Ventilators, axial - roof mounted.
12. Ventilators, centrifugal - ceiling mounted.
13. Ventilators, centrifugal - roof-mounted downblast.
14. Ventilators, centrifugal - roof-mounted upblast and sidewall mounted.
15. Fans, propeller - sidewall mounted.
16. Fans, propeller - roof-mounted upblast.

1.02 ACTION SUBMITTALS

A. Product Data:
1. For each type of product.
a. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
b. Rated capacities, furnished specialties, and accessories for each fan.
c. Fans:
1) Certified fan performance curves with system operating conditions indicated.
2) Certified fan sound-power ratings.
3) Fan construction and accessories.
4) Motor ratings and electrical characteristics, plus motor and electrical accessories.
5) Fan speed controllers.
d. Material thickness and finishes, including color charts.
e. Dampers, including housings, linkages, and operators.

B. Shop Drawings:
1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators [**and seismic restraints**]and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated Design Submittal: For vibration isolation[**, supports,**][**and seismic restraints**] 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 selecting vibration isolators[**, supports,**][**, seismic restraints,**][**and for designing vibration isolation bases**].

D. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans showing fan rooms and fan system layouts, reflected ceiling plans, and other drawings required to illustrate 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.

B. Seismic Qualification Data: Certificates, for fans, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
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.

C. Startup service reports.

D. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fans and ventilators, include the following:

1. Operation in normal and emergency modes.
2. Operation and maintenance manuals.

1.05 MAINTENANCE MATERIAL SUBMITTALS

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

1. Belts: [**One**]<**Insert number**> set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation[**, supports,**][**and seismic restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

F. Seismic Performance: Fans and ventilators are to withstand the effects of earthquake motions determined in accordance with [**ASCE/SEI 7**]<**Insert requirement**>. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. 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. Component Importance Factor: [**1.5**][**1.0**].
3. <Insert requirements for Component Amplification Factor and Component Response Modification Factor>.

G. Capacities and Characteristics:
1. Fan Type: [Centrifugal][Square, inline, centrifugal][Tubular, inline, centrifugal][Plenum][Plug][Utility set].
2. Blade Type: [Forward curved][Backward inclined, airfoil][Backward inclined, curved][Backward inclined, flat].
3. Airflow: <Insert **cfm**>.
4. Total Static Pressure: <**Insert inches wg**>.
5. Class: AMCA 99, Section 14, [**Class I**][**Class II**][**Class III**].
6. Drive Arrangement: <Insert AMCA arrangement number>.
7. Drive Type: [**Belt**][**Direct**].
8. Discharge Arrangement: <Insert discharge arrangement configuration>.
9. Housing Material: [Reinforced steel][Shaped fiberglass-reinforced plastic][Aluminum][Stainless steel].
10. Housing Coating: [None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel]<Insert manufacturer's name and trade name>.
11. Wheel Size (Diameter): <**Insert inches**>.
12. Fan Diameter: <**Insert inches**>.
13. Wheel Material: [Steel][Aluminum][One-piece fiberglass-reinforced plastic][Stainless steel].
14. Wheel Coating: [None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel]; <Insert manufacturer's name and trade name>.
15. Brake Horsepower: <**Insert number**>.
16. Fan rpm: <**Insert value**>.
17. Outlet Velocity: <**Insert fpm**>.
18. Motor:
    a. Motor Enclosure: [Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Explosion proof]<Insert motor enclosure type>.
    b. Enclosure Materials: [Cast iron][Cast aluminum][Rolled steel].
    c. Motor Bearings: <**Insert requirements**>.
    d. Efficiency: Premium efficiency.
    e. NEMA Design: <Insert designation>.
    f. Service Factor: [**1.15**]<**Insert number**>.
    g. Suitable for Use with Variable-Frequency Drive: [**Yes**][**No**].
    h. Electrical Characteristics:
        1) Motor Size: <Insert horsepower>.
        2) Motor Rpm: <**Insert number**>.
        3) Volts: [120][208][230][460]<Insert number> V.
        4) Phase: [**Single**][**Three**].
        5) Hertz: 60 Hz.
        6) Full-Load Amperes: <**Insert number**> A.
        7) Minimum Circuit Ampacity: <**Insert number**> A.
        8) Maximum Overcurrent Protection: <**Insert number**> A.
19. Discharge Sound Power:
    a. 1st Octave: <**Insert dB**>.

b. 2nd Octave: <**Insert dB**>.
c. 3rd Octave: <**Insert dB**>.
d. 4th Octave: <**Insert dB**>.
e. 5th Octave: <**Insert dB**>.
f. 6th Octave: <**Insert dB**>.
g. 7th Octave: <**Insert dB**>.
h. 8th Octave: <**Insert dB**>.

20. Inlet Sound Power:
a. 1st Octave: <**Insert dB**>.
b. 2nd Octave: <**Insert dB**>.
c. 3rd Octave: <**Insert dB**>.
d. 4th Octave: <**Insert dB**>.
e. 5th Octave: <**Insert dB**>.
f. 6th Octave: <**Insert dB**>.
g. 7th Octave: <**Insert dB**>.
h. 8th Octave: <**Insert dB**>.

21. Vibration Isolators: [**Spring**][**Restrained spring**]<**Insert type**> isolators with a static deflection of [**1 inch**]<**Insert deflection**>.
22. Spark-Resistance Class: Classified in accordance with AMCA 99, Section 8, [**Type A**][**Type B**][**Type C**].

H. Service Conditions:
1. Ambient Temperature: <Insert number> **deg F**.
2. Altitude: <**Insert number**> **feet** above sea level.
3. Humidity: <Insert number> **deg F** wet bulb.

2.02 FANS, TUBEAXIAL

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [Airmaster Fan; a brand of MAICO]
4. [American Coolair Corporation]
5. [Carnes Company]
6. [Chicago Blower Corporation]
7. [Cincinnati Fan]
8. [Greenheck Fan Corporation]
9. [Hartzell Fan Incorporated]
10. [Howden American Fan Company]
11. [Loren Cook Company]
12. [New York Blower Company (The)]
13. [Northern Blower, Inc.]
14. [PennBarry; division of Air System Components]
15. [S & P Products]
16. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:
1. [Acme Engineering & Manufacturing Corp.]

2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [Airmaster Fan; a brand of MAICO]
4. [American Coolair Corporation]
5. [Carnes Company]
6. [Chicago Blower Corporation]
7. [Cincinnati Fan]
8. [Greenheck Fan Corporation]
9. [Hartzell Fan Incorporated]
10. [Howden American Fan Company]
11. [Loren Cook Company]
12. [New York Blower Company (The)]
13. [Northern Blower, Inc.]
14. [PennBarry; division of Air System Components]
15. [S & P Products]
16. <Insert manufacturer's name>

C. Source Limitations: Obtain tubeaxial fans from single manufacturer.

D. Standards: Comply with UL 705.

E. Description: Fan wheel and housing, factory-mounted motor with [**belt**][**or**][**direct**] drive, an inlet cone section, and accessories.

F. Housings: [Steel][Galvanized steel][Aluminum][Fiberglass-reinforced plastic][Stainless steel] with flanged inlet and outlet connections.

G. Wheel Assemblies: [Cast or extruded aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key][Fiberglass-reinforced plastic cured under pressure with airfoil-shaped blades keyed to stainless steel shaft][Cast aluminum; machined and fitted to shaft].

H. Belt Drives:
1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: [**1.2**][**1.3**][**1.4**][**1.5**].
3. 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.
4. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through [**5**]<**Insert number**> hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
6. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
7. Belt Guards: Fabricate of prime-coated steel to comply with OSHA and SMACNA requirements for motors with exposed drive belt. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
8. Motor Base: Adjustable rail mount motor base with adjustment screw to set belt tension.
9. Shaft Bearings: Radial, self-aligning bearings.
   a. Ball-Bearing Rating Life: ABMA 9, [**L10 of 50,000 hours**]<**Insert life**>.
   b. Roller-Bearing Rating Life: ABMA 11, [**L10 of 50,000 hours**]<**Insert life**>.
   c. Extend lubrication lines to outside of casing and terminate with grease fittings.

I. 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. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
5. Mounting Clips: [**Horizontal ceiling**][**Vertical mounting**] clips welded to fan housing, of same material as housing.
6. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
7. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
8. Inlet Screen: On unducted fan inlet - wire-mesh screen, of same material as housing.
9. Outlet Screen: On unducted fan outlet - wire-mesh screen, of same material as housing.
10. Backdraft Dampers: Butterfly style, for bolting to fan discharge or outlet cone, of same material as housing.
11. Shaft Seal: Elastomeric seal and PTFE wear plate, suitable for up to **300 deg F**.
12. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
13. 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.
14. Inlet Bell: Curved inlet for when fan is not attached to duct[**, of same material as housing**][**; aluminum**].
15. Inlet Cone: Round-to-round transition, of same material as housing.
16. Outlet Cone: Round-to-round transition, of same material as housing.
17. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
18. Direct-Driven Units: Encase motor in housing outside of airstream. Extend lubrication lines to outside of casing and terminate with grease fittings.
19. [Factory-wired motor disconnect switch located on outside of fan housing.]

J. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: [Epoxy][Zinc][Phenolic][Powder-baked enamel]; <Insert manufacturer's name and trade name>.
   a. Apply to finished housings.
   b. Apply to fan wheels.

2.03 FANS, VANEAXIAL

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [American Coolair Corporation]
4. [Chicago Blower Corporation]
5. [Greenheck Fan Corporation]
6. [Hartzell Fan Incorporated]

7. [Howden American Fan Company]
8. [Loren Cook Company]
9. [New York Blower Company (The)]
10. [Northern Blower, Inc.]
11. [PennBarry; division of Air System Components]
12. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:
1. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [American Coolair Corporation]
4. [Chicago Blower Corporation]
5. [Greenheck Fan Corporation]
6. [Hartzell Fan Incorporated]
7. [Howden American Fan Company]
8. [Loren Cook Company]
9. [New York Blower Company (The)]
10. [Northern Blower, Inc.]
11. [PennBarry; division of Air System Components]
12. <Insert manufacturer's name>

C. Source Limitations: Obtain vaneaxial fans from single manufacturer.

D. Standards: Comply with UL 705.

E. Description: Fan wheel and housing, straightening vane section, factory-mounted motor with belt or direct drive, an inlet cone section, and accessories.
1. Variable-Pitch Fans: Internally mounted [**electric**][**electronic**] actuator, externally mounted positive positioner, and mechanical-blade-pitch indicator.

F. Housings: [Steel][Aluminum][Fiberglass-reinforced plastic][Stainless steel]<Insert material>.
1. Inlet and Outlet Connections: Flanges.
2. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.

G. Wheel Assemblies: [Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key][Fiberglass-reinforced plastic cured under pressure with airfoil-shaped blades keyed to stainless steel shaft][Cast-aluminum hub assembly, machined and fitted with threaded bearing wells to receive blade-bearing assemblies with replaceable, cast-aluminum blades; factory mounted and balanced].

H. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
1. Service Factor Based on Fan Motor Size: [**1.2**][**1.3**][**1.4**][**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.
4. Motor Pulleys: Adjustable pitch for use with motors through [**5**]<**Insert number**> hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Fabricate of prime-coated steel to comply with OSHA and SMACNA requirements for motors with exposed drive belt. Include provisions for adjustment of

belt tension, lubrication, and use of tachometer with guard in place.

7. Motor Base: Adjustable rail mount motor base with adjustment screw to set belt tension.
8. Shaft Bearings: Radial, self-aligning bearings.
   a. Ball-Bearing Rating Life: ABMA 9, [**L10 of 100,000 hours**]<**Insert life**>.
   b. Roller-Bearing Rating Life: ABMA 11, [**L10 of 100,000 hours**]<**Insert life**>.
   c. Extend lubrication lines to outside of casing and terminate with grease fittings.

I. 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. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
5. Mounting Clips: [**Horizontal ceiling**][**Vertical mounting**] clips welded to fan housing, of same material as housing.
6. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
7. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
8. Inlet Screen: On unducted fan inlet - wire-mesh screen, of same material as housing.
9. Outlet Screen: On unducted fan outlet - wire-mesh screen, of same material as housing.
10. Backdraft Dampers: Butterfly style, for mounting with flexible connection to fan discharge or direct mounted to discharge diffuser section, of same material as housing.
11. 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 Section 230923.23 "Pressure Instruments" and Section 230993.11 "Sequence of Operations for HVAC DDC."
12. Flow Measurement Port: Pressure measurement taps installed in fan inlet to detect and signal airflow readings to temperature-control systems. Control devices and sequence of operation are specified in Section 230923.14 "Flow Instruments" and Section 230993.11 "Sequence of Operations for HVAC DDC."
13. Shaft Seal: Elastomeric seal and PTFE wear plate, suitable for up to **300 deg F**.
14. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
15. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
16. Inlet Cone: Round-to-round transition, of same material as housing.
17. Outlet Cone: Round-to-round transition, of same material as housing.
18. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
19. Direct-Driven Units: Encase motor in housing outside of airstream. Extend lubrication lines to outside of casing and terminate with grease fittings.
20. [Factory-wired motor disconnect switch located on outside of fan housing.]

J. Factory Finishes:
1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: [Epoxy][Zinc][Phenolic][Powder-baked enamel]; <Insert manufacturer's name and trade name>.
a. Apply to finished housings.
b. Apply to fan wheels.

2.04 FANS, MIXED FLOW

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Acme Engineering & Manufacturing Corp.]
2. [Greenheck Fan Corporation]
3. [Howden American Fan Company]
4. [Loren Cook Company]
5. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:
1. [Acme Engineering & Manufacturing Corp.]
2. [Greenheck Fan Corporation]
3. [Howden American Fan Company]
4. [Loren Cook Company]
5. <Insert manufacturer's name>

C. Source Limitations: Obtain mixed-flow fans from single manufacturer.

D. Standards: Comply with UL 705.

E. Description: Fan wheel and housing,[**straightening vane section,**] factory-mounted motor with [**belt drive**][**or**][**direct drive**], and accessories.

F. Housings: [Steel][Galvanized steel][Aluminum].
1. Inlet and Outlet Connections: Outer mounting frame and companion flanges.
2. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.
3. Mixed-Flow Outlet Connection: [**One**][**Two**] flanged discharge(s) perpendicular to fan inlet.

G. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

H. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
1. Service Factor Based on Fan Motor Size: [**1.2**][**1.3**][**1.4**][**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.
4. Motor Pulleys: Adjustable pitch for use with motors through [**5**]<**Insert number**> hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Motor Base: Adjustable rail mount motor base with adjustment screw to set belt tension.

7. Shaft Bearings: Radial, self-aligning bearings.
   a. Ball-Bearing Rating Life: ABMA 9, [**L10 of 100,000 hours**]<**Insert life**>.
   b. Roller-Bearing Rating Life: ABMA 11, [**L10 of 100,000 hours**]<**Insert life**>.
   c. Extend lubrication lines to outside of casing and terminate with grease fittings.

I. Accessories:
   1. Mounting Clips: [**Horizontal ceiling**][**Vertical mounting**] clips welded to fan housing, of same material as housing.
   2. Inlet and Outlet Screens: On unducted fan inlet and outlet - wire-mesh screen, of same material as housing.
   3. Backdraft Dampers: Butterfly style, for mounting with flexible connection to fan discharge or direct mounted to 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.
   9. Belt Guard: Fabricate of prime-coated steel to comply with OSHA and SMACNA requirements for motors with exposed drive belt. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
   10. Direct-Driven Units: Encase motor in housing outside of airstream.
   11. [Factory-wired motor disconnect switch located on outside of fan housing.]

J. Factory Finishes:
   1. Sheet Metal Parts: Prime coat before final assembly.
   2. Exterior Surfaces: Baked-enamel finish coat after assembly.
   3. Coatings: [Epoxy][Zinc][Phenolic][Powder-baked enamel]; <Insert manufacturer's name and trade name>.
      a. Apply to finished housings.
      b. Apply to fan wheels.

2.05 FANS, CENTRIFUGAL - BACKWARD-INCLINED BLADES

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Acme Engineering & Manufacturing Corp.]
   2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
   3. [Canarm Ltd.]
   4. [Central Blower Company]
   5. [Chicago Blower Corporation]
   6. [Cincinnati Fan]
   7. [COMEFRI]
   8. [Loren Cook Company]
   9. [New York Blower Company (The)]
   10. [Northern Blower, Inc.]
   11. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [Canarm Ltd.]
4. [Central Blower Company]
5. [Chicago Blower Corporation]
6. [Cincinnati Fan]
7. [COMEFRI]
8. [Loren Cook Company]
9. [New York Blower Company (The)]
10. [Northern Blower, Inc.]
11. <Insert manufacturer's name>

C. Source Limitations: Obtain backward-inclined centrifugal fans from single manufacturer.

D. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, [**belt-**][**direct-**]driven centrifugal fans, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
2. Factory-installed and -wired disconnect switch.

E. Standards: Comply with UL 705.

F. Housings:

1. Housing Material: [Reinforced steel][Shaped fiberglass-reinforced plastic][Aluminum][Stainless steel][See schedule]<Insert material>.
2. Housing Coating: [None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>.
3. Housing Assembly: Sideplates[continuously welded][or][spot welded][or][attached by continuous Pittsburgh lock seal or similar seal].
4. Formed panels to make curved-scroll housings with shaped cutoff.
5. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
6. Horizontally split, bolted-flange housing.
7. Spun inlet cone with flange.
8. Outlet flange.
9. Discharge Arrangement: Fan scroll housing is field rotatable to any of [**seven**][**eight**] discharge positions. Provide fan with discharge positioned in proper direction to minimize connected duct turns.

G. Wheels:

1. Wheel Configuration: [**SWSI**][**DWDI**] construction with a precision-spun curved inlet flange and a backplate fastened to shaft with setscrews. Wheels are to be statically and dynamically balanced, and nonoverloading.
2. Wheel and Blade Material: [Steel][Aluminum][One-piece fiberglass-reinforced plastic][Stainless steel][See schedule].
3. Spark-Resistant Construction: Classified in accordance with AMCA 99, Section 8, [**Type A**][**Type B**][**Type C**].
4. Wheel and Blade Coating: [None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>.

5. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
6. Backward-Inclined Airfoil Blades:
   a. Aerodynamic design.
   b. Heavy backplate.
   c. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
7. Backward-Inclined Curved Blades:
   a. Curved design.
   b. Heavy backplate.
   c. Single-thickness blades continuously welded at tip flange and backplate.

H. Shafts:
1. Statically and dynamically balanced, and selected for continuous operation at maximum-rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

I. Bearings:
1. Prelubricated and Sealed Shaft Bearings:
   a. Self-aligning, pillow-block-type ball bearings.
   b. Ball-Bearing Rating Life: ABMA 9, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
   c. Roller-Bearing Rating Life: ABMA 11, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
2. Grease-Lubricated Shaft Bearings, Tapered Roller:
   a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
   b. Roller-Bearing Rating Life: ABMA 11, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
   c. Extended Lubrication Lines: Extend lines to accessible location.
3. Grease-Lubricated Shaft Bearings, Ball or Roller:
   a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
   b. Ball-Bearing Rating Life: ABMA 9, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
   c. Roller-Bearing Rating Life: ABMA 11, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
   d. Extended Lubrication Lines: Extend lines to accessible location.

J. Belt Drives:
1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: [**1.5**][**1.4**][**1.3**][**1.2**].
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through [**5**]<**Insert number**> hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch pulleys for use with motors larger than [**5**]<**Insert number**> hp.

5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; [**0.146-inch-**]<**Insert dimension**> thick, [**3/4-inch**]<**Insert dimension**> 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.
7. Motor Mount: Adjustable for belt tensioning.

K. Motor Enclosure: [Open, dripproof][Totally enclosed, fan cooled][Explosion proof][Totally enclosed, air over]<Insert motor enclosure type>.

L. Accessories:
1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Scroll Drain Connection: **NPS 1** steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Discharge Dampers: Assembly with [**parallel**][**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.
5. Inlet Screens: Grid screen of same material as housing.
6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
7. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
8. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
9. Piezometer Ring: Piezometer ring mounted at fan inlet cone for airflow measurement.

2.06 FANS, CENTRIFUGAL - FORWARD-CURVED BLADES

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Acme Engineering & Manufacturing Corp.]
2. [Canarm Ltd.]
3. [Central Blower Company]
4. [Lau Fan]
5. [New York Blower Company (The)]
6. [Plastec Ventilation Inc.]
7. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:
1. [Acme Engineering & Manufacturing Corp.]
2. [Canarm Ltd.]
3. [Central Blower Company]
4. [Lau Fan]
5. [New York Blower Company (The)]
6. [Plastec Ventilation Inc.]
7. <Insert manufacturer's name>

C. Source Limitations: Obtain forward-curved blade centrifugal fans from single manufacturer.
D. Description:
   1. Factory-fabricated, -assembled, -tested, and -finished, [**belt-**][**direct-**]driven centrifugal fans, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
   2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
   3. Factory-installed and -wired disconnect switch.
E. Standards: Comply with UL 705.
F. Housings:
   1. Housing Material: [Reinforced steel][Shaped fiberglass-reinforced plastic][Aluminum][Stainless steel][See schedule].
   2. Housing Coating: [None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>.
   3. Housing Assembly: Sideplates [continuously welded][or][spot welded][or][attached by continuous Pittsburgh lock seal or similar seal].
   4. Formed panels to make curved-scroll housings with shaped cutoff.
   5. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
   6. Horizontally split, bolted-flange housing.
   7. Spun inlet cone with flange.
   8. Outlet flange.
   9. Discharge Arrangement: Fan scroll housing field rotatable to any of [**seven**][**eight**] discharge positions. Provide fan with discharge positioned in proper direction to minimize connected duct turns.
G. Wheels:
   1. Wheel Configuration: [**SWSI**][**DWDI**] construction with a curved inlet flange and a backplate fastened to shaft with setscrews.
   2. Wheel and Blade Material: [Steel][Aluminum][One-piece fiberglass-reinforced plastic][Stainless steel][See schedule].
      a. Spark-Resistant Construction: Classified in accordance with AMCA 99, Section 8, [**Type A**][**Type B**][**Type C**].
   3. Wheel and Blade Coating: [None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>.
   4. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with setscrews.
   5. Forward-Curved Wheels:
      a. Black-enameled or galvanized-steel construction with inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow.
      b. Mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with setscrews.
H. Shafts:
   1. Statically and dynamically balanced and selected for continuous operation at maximum-rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
   2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
   3. Designed to operate at no more than 70 percent of first critical speed at top of fan's

speed range.

I. Bearings:
   1. Prelubricated and Sealed Shaft Bearings:
      a. Self-aligning, pillow-block-type [**ball**][**roller**] bearings.
      b. Ball-Bearing Rating Life: ABMA 9, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
      c. Roller-Bearing Rating Life: ABMA 11, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
   2. Grease-Lubricated Shaft Bearings, Tapered Roller:
      a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
      b. Roller-Bearing Rating Life: ABMA 11, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
      c. Extended Lubrication Lines: Extend lines to accessible location.
   3. Grease-Lubricated Shaft Bearings, Ball or Roller:
      a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
      b. Ball-Bearing Rating Life: ABMA 9, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
      c. Roller-Bearing Rating Life: ABMA 11, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
      d. Extended Lubrication Lines: Extend lines to accessible location.

J. Belt Drives:
   1. Factory mounted, with adjustable alignment and belt tensioning.
   2. Service Factor Based on Fan Motor Size: [**1.5**][**1.4**][**1.3**][**1.2**].
   3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   4. Motor Pulleys: Adjustable pitch for use with motors through [**5**]<**Insert number**> hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than [**5**]<**Insert number**> hp.
   5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   6. Belt Guards: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; [**0.146-inch-**]<**Insert dimension**> thick, [**3/4-inch**]<**Insert dimension**> 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.
   7. Motor Mount: Adjustable for belt tensioning.

K. Motor Enclosure: [Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Explosion proof].

L. Accessories:
   1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
   2. Scroll Drain Connection: **NPS 1** steel pipe coupling welded to low point of fan scroll.
   3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
   4. Discharge Dampers: Assembly with [**parallel**][**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.
5. Inlet Screens: Grid screen of same material as housing.
6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
7. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
8. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
9. Piezometer Ring: Piezometer ring mounted at fan inlet cone for airflow measurement.

2.07 FANS, CENTRIFUGAL, INLINE - SQUARE

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [American Coolair Corporation]
4. [Canarm Ltd.]
5. [Carnes Company]
6. [FloAire National]
7. [Greenheck Fan Corporation]
8. [JencoFan]
9. [Loren Cook Company]
10. [PennBarry; division of Air System Components]
11. [Quietaire Inc.]
12. [Rupp Air Management Systems]
13. [S & P USA Ventilation Systems, LLC]
14. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:
1. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [American Coolair Corporation]
4. [Canarm Ltd.]
5. [Carnes Company]
6. [FloAire National]
7. [Greenheck Fan Corporation]
8. [JencoFan]
9. [Loren Cook Company]
10. [PennBarry; division of Air System Components]
11. [Quietaire Inc.]
12. [Rupp Air Management Systems]
13. [S & P USA Ventilation Systems, LLC]
14. <Insert manufacturer's name>

C. Source Limitations: Obtain square inline centrifugal fans from single manufacturer.
D. Description: Square-housing in-line centrifugal fans.
E. Standards: Comply with UL 705.
F. Housing:

1. Housing Material: [Reinforced steel][Aluminum][Stainless steel][See schedule]<Insert material>.
2. Housing Coating: [None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>.
3. Housing Construction: Side panels are to be easily removable for service. Include inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

G. Direct-Drive 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**].

H. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosures around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

I. Fan Wheels: Aluminum airfoil blades welded to aluminum hub.

J. Motor Enclosure: [Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Explosion-proof]<Insert motor enclosure type>.

K. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
3. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
4. Companion Flanges: For inlet and outlet duct connections.
5. Fan Guards: **1/2- by 1-inch** mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
6. Motor: Epoxy-coated steel.
7. Belt Guards: Fabricate of prime-coated steel to comply with OSHA and SMACNA requirements for motors with exposed drive belt. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
8. Side Discharge: Flange connector and attachment hardware to provide right-angle discharge on side of unit.

2.08 FANS, CENTRIFUGAL, INLINE - TUBULAR

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [American Coolair Corporation]
4. [Hartzell Fan Incorporated]
5. [JencoFan]
6. [Loren Cook Company]
7. [New York Blower Company (The)]
8. [Peerless Blowers]
9. [PennBarry; division of Air System Components]
10. [S & P USA Ventilation Systems, LLC]
11. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert**

manufacturer's name; product name or designation> or comparable product by one of the following:

1. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [American Coolair Corporation]
4. [Hartzell Fan Incorporated]
5. [JencoFan]
6. [Loren Cook Company]
7. [New York Blower Company (The)]
8. [Peerless Blowers]
9. [PennBarry; division of Air System Components]
10. [S & P USA Ventilation Systems, LLC]
11. <Insert manufacturer's name>

C. Source Limitations: Obtain tubular in-line centrifugal fans from single manufacturer.

D. Description: Tubular-housing in-line centrifugal fans.

E. Housing:

1. Housing Material: [Reinforced steel][Shaped fiberglass-reinforced plastic][Aluminum][Stainless steel][See schedule]<Insert material>.
2. Housing Coating: [None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>.
3. Housing Construction: Split, [**spun aluminum**]with [**aluminum**]straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

F. Direct-Drive 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**].

G. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

H. Fan Wheels: [**Steel**][**Aluminum**], airfoil blades welded to aluminum hub.

I. Motor Enclosure: [Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Explosion proof]<Insert motor enclosure type>.

J. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
3. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
4. Companion Flanges: For inlet and outlet duct connections.
5. Fan Guards: **1/2- by 1-inch** mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
6. Motor Cover: Epoxy-coated steel.
7. Belt Guard: Fabricate of prime-coated steel to comply with OSHA and SMACNA requirements for motors with exposed drive belt. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

2.09 FANS, PLENUM

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Aerovent; a division of Twin City Fan Companies, Ltd.]
2. [Chicago Blower Corporation]
3. [Cincinnati Fan]
4. [COMEFRI]
5. [Loren Cook Company]
6. [New York Blower Company (The)]
7. [Northern Blower, Inc.]
8. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:

1. [Aerovent; a division of Twin City Fan Companies, Ltd.]
2. [Chicago Blower Corporation]
3. [Cincinnati Fan]
4. [COMEFRI]
5. [Loren Cook Company]
6. [New York Blower Company (The)]
7. [Northern Blower, Inc.]
8. <Insert manufacturer's name>

C. Source Limitations: Obtain plenum fans from single manufacturer.

D. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, [**belt-**][**direct-**]driven centrifugal fans, consisting of wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. [Factory-installed and -wired disconnect switch.]

E. Standards: Comply with UL 705.

F. Wheels:

1. Wheel Configuration: SWSI construction with curved inlet flange and heavy backplate; fastened to shaft with setscrews.
2. Wheel and Blade Material: [Steel][Aluminum][One-piece fiberglass-reinforced plastic][Stainless steel][See schedule].
   a. Spark-Resistant Construction: Classified in accordance with AMCA 99, Section 8, [**Type A**][**Type B**][**Type C**].
3. Wheel and Blade Coating: [None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>.
4. Backward-Inclined Airfoil Blades: Hollow, die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.

G. Shafts:

1. Statically and dynamically balanced, and selected for continuous operation at maximum-rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's

speed range.

H. Bearings:
1. Prelubricated and Sealed Shaft Bearings:
a. Self-aligning, pillow-block-type ball bearings.
b. Ball-Bearing Rating Life: ABMA 9, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
c. Roller-Bearing Rating Life: ABMA 11, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
2. Grease-Lubricated Shaft Bearings, Tapered Roller:
a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
b. Roller-Bearing Rating Life: ABMA 11, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
c. Extended Lubrication Lines: Extend lines to accessible location.
3. Grease-Lubricated Shaft Bearings, Ball or Roller:
a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
b. Ball-Bearing Rating Life: ABMA 9, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
c. Roller-Bearing Rating Life: ABMA 11, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
d. Extended Lubrication Lines: Extend lines to accessible location.

I. Belt Drives:
1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: [**1.5**][**1.4**][**1.3**][**1.2**].
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through [**5**]<**Insert number**> hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than [**5**]<**Insert number**> hp.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; [**0.146-inch-**]<**Insert dimension**> thick, [**3/4-inch**] 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.
7. Motor Mount: Adjustable for belt tensioning.

J. Motor Enclosure: [Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Explosion proof].

K. Accessories:
1. Inlet Safety Screen: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
2. Safety Enclosure: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
3. Belt Guard: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC

Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.

4. Inlet Companion Flange: Rolled flanges for duct connections of same material as housing.
5. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
6. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
7. Piezometer Ring: Piezometer ring mounted at fan inlet cone for airflow measurement.

2.10 FANS, PLUG

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Aerovent; a division of Twin City Fan Companies, Ltd.]
   2. [Chicago Blower Corporation]
   3. [Cincinnati Fan]
   4. [Loren Cook Company]
   5. [New York Blower Company (The)]
   6. [Northern Blower, Inc.]
   7. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
   1. [Aerovent; a division of Twin City Fan Companies, Ltd.]
   2. [Chicago Blower Corporation]
   3. [Cincinnati Fan]
   4. [Loren Cook Company]
   5. [New York Blower Company (The)]
   6. [Northern Blower, Inc.]
   7. <Insert manufacturer's name>

C. Source Limitations: Obtain plug fans from single manufacturer.

D. Description:
   1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans, consisting of wheel, fan shaft, bearings, motor, drive assembly, and support structure.
   2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
   3. Factory-installed and -wired disconnect switch.

E. Standards: Comply with UL 705.

F. Wheels:
   1. Wheel Configuration: SWSI construction with curved inlet flange and heavy backplate; fastened to shaft with setscrews.
   2. Wheel and Blade Material: [Steel][Aluminum][One-piece fiberglass-reinforced plastic][Stainless steel][See schedule].
      a. Spark-Resistant Construction: Classified in accordance with AMCA 99, Section 8 [**Type A**][**Type B**][**Type C**].
   3. Wheel and Blade Coating: [None][Themoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert

manufacturer's name and trade name>.

4. Backward-Inclined Airfoil Blades: Hollow, die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.

G. Shafts:
1. Statically and dynamically balanced, and selected for continuous operation at maximum-rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

H. Bearings:
1. Prelubricated and Sealed Shaft Bearings:
   a. Self-aligning, pillow-block-type ball bearings.
   b. Ball-Bearing Rating Life: ABMA 9, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
   c. Roller-Bearing Rating Life: ABMA 11, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
2. Grease-Lubricated Shaft Bearings, Tapered Roller:
   a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
   b. Ball-Bearing Rating Life: ABMA 9, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
   c. Roller-Bearing Rating Life: ABMA 11, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
   d. Extended Lubrication Lines: Extend lines to accessible location.
3. Grease-Lubricated Shaft Bearings, Ball or Roller:
   a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
   b. Ball-Bearing Rating Life: ABMA 9, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
   c. Roller-Bearing Rating Life: ABMA 11, L10 at [**50,000**][**120,000**]<**Insert number**> hours.
   d. Extended Lubrication Lines: Extend lines to accessible location.

I. Belt Drives:
1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: [**1.5**][**1.4**][**1.3**][**1.2**].
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through [**5**]<**Insert number**> hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with larger motors.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; [**0.146-inch-**]<**Insert dimension**> thick, [**3/4-inch**]<**Insert dimension**> 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.

7. Motor Mount: Adjustable for belt tensioning.

J. Motor Enclosure: [Open, dripproof][Totally enclosed, fan cooled][Totally enclosed, air over][Explosion proof].

K. Accessories:

1. Inlet Safety Screen: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
2. Safety Enclosure: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
3. Belt Guard: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
4. Inlet Companion Flange: Rolled flanges for duct connections of same material as housing.
5. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
6. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

2.11 FANS, UTILITY SET

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Aerovent; a division of Twin City Fan Companies, Ltd.]
2. [American Coolair Corporation]
3. [Canarm Ltd.]
4. [Carnes Company]
5. [Delhi Industries Inc]
6. [JencoFan]
7. [Loren Cook Company]
8. [New York Blower Company (The)]
9. [Peerless Blowers]
10. [PennBarry; division of Air System Components]
11. [Quietaire Inc.]
12. [Rupp Air Management Systems]
13. [S & P USA Ventilation Systems, LLC]
14. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:

1. [Aerovent; a division of Twin City Fan Companies, Ltd.]
2. [American Coolair Corporation]
3. [Canarm Ltd.]
4. [Carnes Company]
5. [Delhi Industries Inc]
6. [JencoFan]
7. [Loren Cook Company]
8. [New York Blower Company (The)]
9. [Peerless Blowers]

10. [PennBarry; division of Air System Components]
11. [Quietaire Inc.]
12. [Rupp Air Management Systems]
13. [S & P USA Ventilation Systems, LLC]
14. <Insert manufacturer's name>

C. Source Limitations: Obtain fan utility sets from single manufacturers.

D. Description:
1. Factory-fabricated, -assembled, -tested, and -finished, [**belt-**][**direct-**]driven centrifugal fan utility vent sets, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.

E. Standards: Comply with UL 705.

F. Housings:
1. Housing Material: [Reinforced steel][Shaped fiberglass-reinforced plastic][Aluminum][Stainless steel][See schedule]<Insert material>.
2. Housing Coating: [None][Themoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>.
3. Formed panels to make curved-scroll housings with shaped cutoff.
4. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
5. Discharge Arrangement: Fan scroll housing field rotatable to any of [**seven**][**eight**] discharge positions. Provide fan with discharge positioned in proper direction to minimize connected duct turns.

G. Wheels:
1. Wheel Configuration: SWSI, with hub keyed to shaft.
2. Wheel and Blade Materials: [Steel][Aluminum][One-piece fiberglass-reinforced plastic][Stainless steel][See schedule].
   a. Spark-Resistant Construction: Classified in accordance with AMCA 99, Section 8 [**Type A**][**Type B**][**Type C**].
3. Wheel and Blade Coating: [None][Thermoplastic vinyl][Epoxy][Synthetic resin][Phenolic][Hot-dip galvanized][Powder-baked enamel][See schedule]<Insert manufacturer's name and trade name>.
4. Backward-Inclined Airfoil Blades:
   a. Aerodynamic design.
   b. Heavy backplate.
   c. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
5. Backward-Inclined Curved Blades:
   a. Curved design.
   b. Heavy backplate.
   c. Single-thickness blades continuously welded at tip flange and backplate.
6. Backward-Inclined Flat Blades:
   a. Flat design.
   b. Heavy backplate.
   c. Single-thickness blades continuously welded at tip flange and backplate.
7. Forward-Curved Blades:
   a. Curved design.
   b. Heavy backplate.
   c. Single-thickness blades continuously welded or riveted at tip flange and backplate.

H. Shafts:
   1. Turned, ground, and polished steel; keyed to wheel hub. First critical speed at least 1.4 times maximum class speed.

I. Bearings:
   1. Heavy-duty regreasable ball or roller type in a cast-iron pillowblock housing.
   2. Ball-Bearing Rating Life: ABMA 9, [L50 of 200,000 hours][L10 of 80,000 hours]<Insert life>.
   3. Roller-Bearing Rating Life: ABMA 11, [L50 of 200,000 hours][L10 of 80,000 hours]<Insert life>.
   4. Extend grease fitting to accessible location outside of unit.

J. Belt Drive:
   1. Factory mounted, with final alignment and belt adjustment made after installation.
   2. Service Factor Based on Fan Motor Size: [**1.5**][**1.4**][**1.3**][**1.2**].
   3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   4. Motor Pulleys: Adjustable pitch for use with motors through [**5**]<**Insert value**> hp; fixed pitch for use with motors larger than [**5**]<**Insert number**> hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
   5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   6. Belt Guards: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," [**0.146-inch-**]<**Insert dimension**> thick, [**3/4-inch**]<**Insert dimension**> 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.

K. Motor Enclosure: [Open, dripproof][Totally enclosed, fan cooled][Explosion proof]<Insert motor enclosure type>.

L. Accessories:
   1. Inlet and Outlet: Flanged.
   2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
   3. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades, with felt edges in steel frame installed on fan discharge.
   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.
   7. Outlet Screens: Removable wire mesh.
   8. Belt Guard: OSHA-compliant, fabricated in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen welded to steel angle frame or equivalent, prime coated.
   9. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
   10. Drain Connections: **NPS 3/4** threaded coupling drain connection installed at lowest point of housing.
   11. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
   12. Discharge Dampers: Assembly with [**parallel**][**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.

13. Grease Collection Trough and Receiver: For restaurant exhaust application.
14. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

2.12 VENTILATORS, AXIAL - ROOF MOUNTED

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Acme Engineering & Manufacturing Corp.]
   2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
   3. [Airmaster Fan; a brand of MAICO]
   4. [American Coolair Corporation]
   5. [Broan.; a Broan-NuTone LLC brand; a Nortek company]
   6. [FloAire National]
   7. [Greenheck Fan Corporation]
   8. [Hartzell Fan Incorporated]
   9. [JencoFan]
   10. [Loren Cook Company]
   11. [Moffitt Corporation]
   12. [New York Blower Company (The)]
   13. [PennBarry; division of Air System Components]
   14. [Quietaire Inc.]
   15. [Rupp Air Management Systems]
   16. [S & P USA Ventilation Systems, LLC]
   17. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:
   1. [Acme Engineering & Manufacturing Corp.]
   2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
   3. [Airmaster Fan; a brand of MAICO]
   4. [American Coolair Corporation]
   5. [Broan.; a Broan-NuTone LLC brand; a Nortek company]
   6. [FloAire National]
   7. [Greenheck Fan Corporation]
   8. [Hartzell Fan Incorporated]
   9. [JencoFan]
   10. [Loren Cook Company]
   11. [Moffitt Corporation]
   12. [New York Blower Company (The)]
   13. [PennBarry; division of Air System Components]
   14. [Quietaire Inc.]
   15. [Rupp Air Management Systems]
   16. [S & P USA Ventilation Systems, LLC]
   17. <Insert manufacturer's name>

C. Source Limitations: Obtain roof-mounted axial ventilators from single manufacturer.

D. Standards: Comply with UL 705.

E. Housing: Heavy-gauge, removable, spun-aluminum dome top and outlet baffle; square, one-piece, hinged, aluminum base.
F. Fan Wheel: [Aluminum][Steel] hub and blades. [Spark-resistant construction classified in accordance with AMCA 99, Section 8,][Type A][Type B][Type C].
G. Belt Drives:
   1. Resiliently mounted to housing.
   2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
   4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   5. Motor Pulleys: Adjustable pitch for use with motors through [**5**]<**Insert number**> hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than [**5**]<**Insert number**> hp.
H. Accessories:
   1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted [**inside**][**outside**] fan housing, factory wired through an internal aluminum conduit.
   2. Bird Screens: Removable, **1/2-inch** mesh, aluminum or brass wire.
   3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
   4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
   5. Stack hood with built-in backdraft dampers.
   6. Extended lubrication lines.
I. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; **1-1/2-inch-**thick, rigid, fiberglass insulation adhered to inside walls; and **1-1/2-inch** wood nailer. Size as required to suit roof opening and fan base.
   1. Configuration: [Self-flashing without a cant strip, with mounting flange][Built-in cant and mounting flange][Built-in raised cant and mounting flange].
   2. Overall Height: [**8 inches**][**9-1/2 inches**][**12 inches**][**16 inches**][**18 inches**].
   3. Sound Curb: Curb with sound-absorbing insulation.
   4. Pitch Mounting: Manufacture curb for roof slope.
   5. Metal Liner: Galvanized steel.
   6. Burglar Bars: [**1/2-inch-**][**5/8-inch-**][**3/4-inch-**] thick steel bars welded in place to form **6-inch** squares.
   7. Mounting Pedestal: Galvanized steel with removable access panel.

2.13 VENTILATORS, CENTRIFUGAL - CEILING MOUNTED

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Acme Engineering & Manufacturing Corp.]
   2. [American Coolair Corporation]
   3. [Broan.; a Broan-NuTone LLC brand; a Nortek company]
   4. [Canarm Ltd.]
   5. [Carnes Company]
   6. [FloAire National]
   7. [Greenheck Fan Corporation]

8. [JencoFan]
9. [Loren Cook Company]
10. [Panasonic Eco Solutions]
11. [PennBarry; division of Air System Components]
12. [S & P USA Ventilation Systems, LLC]
13. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:
1. [Acme Engineering & Manufacturing Corp.]
2. [American Coolair Corporation]
3. [Broan.; a Broan-NuTone LLC brand; a Nortek company]
4. [Canarm Ltd.]
5. [Carnes Company]
6. [FloAire National]
7. [Greenheck Fan Corporation]
8. [JencoFan]
9. [Loren Cook Company]
10. [Panasonic Eco Solutions]
11. [PennBarry; division of Air System Components]
12. [S & P USA Ventilation Systems, LLC]
13. <Insert manufacturer's name>

C. Source Limitations: Obtain ceiling-mounted centrifugal ventilators from single manufacturer.

D. Standards: Comply with UL 705.

E. Housing: Steel, lined with acoustical insulation.

F. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel are removable for service.

G. Back-draft damper: Integral.

H. Grille: [**Plastic**][**Stainless steel**][**Aluminum**][**Painted aluminum**], louvered grille with flange on intake and thumbscrew or spring retainer attachment to fan housing.

I. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

J. Accessories:
1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Motion Sensor: Motion detector with adjustable shutoff timer.
5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless steel springs, and fusible link.
6. Filter: Washable aluminum to fit between fan and grille.
7. Isolation: Rubber-in-shear vibration isolators.
8. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.14 VENTILATORS, CENTRIFUGAL - ROOF-MOUNTED DOWNBLAST

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [Airmaster Fan; a brand of MAICO]
4. [American Coolair Corporation]
5. [Carnes Company]
6. [FloAire National]
7. [Greenheck Fan Corporation]
8. [JencoFan]
9. [Loren Cook Company]
10. [New York Blower Company (The)]
11. [Northern Blower, Inc.]
12. [PennBarry; division of Air System Components]
13. [Quietaire Inc.]
14. [Rupp Air Management Systems]
15. [S & P USA Ventilation Systems, LLC]
16. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:
   1. [Acme Engineering & Manufacturing Corp.]
   2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
   3. [Airmaster Fan; a brand of MAICO]
   4. [American Coolair Corporation]
   5. [Carnes Company]
   6. [FloAire National]
   7. [Greenheck Fan Corporation]
   8. [JencoFan]
   9. [Loren Cook Company]
   10. [New York Blower Company (The)]
   11. [Northern Blower, Inc.]
   12. [PennBarry; division of Air System Components]
   13. [Quietaire Inc.]
   14. [Rupp Air Management Systems]
   15. [S & P USA Ventilation Systems, LLC]
   16. <Insert manufacturer's name>

C. Source Limitations: Obtain roof-mounted downblast centrifugal ventilators from single manufacturer.

D. Standards: Comply with UL 705.

E. Housing: Downblast; removable [spun-aluminum dome top and outlet baffle][extruded-aluminum rectangular top][galvanized-steel mushroom-domed top][spun aluminum]; square, one-piece aluminum base with venturi inlet cone.

F. Fan Wheels: Aluminum hub and wheel with backward-inclined blades[; spark-resistant construction classified in accordance with AMCA 99, Section 8,][Type A][Type B][Type C].

G. Belt Drives:
   1. Resiliently mounted to housing.
   2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
   4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced

at factory.

5. Motor Pulleys: Adjustable pitch for use with motors through [**5**]<**Insert number**> hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than [**5**]<**Insert number**> hp.
6. Fan and motor are isolated from exhaust airstream.

H. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted [**inside**][**outside**] fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, **1/2-inch** 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.
6. Spark-resistant, all-aluminum wheel construction.
7. Mounting Pedestal: Galvanized steel with removable access panel.

I. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; **1-1/2-inch-**thick, rigid, fiberglass insulation adhered to inside walls; and **1-1/2-inch** wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: [Self-flashing without a cant strip, with mounting flange][Built-in cant and mounting flange][Built-in raised cant and mounting flange][Manufactured to accommodate roof slope].
2. Overall Height: [**8 inches**][**9-1/2 inches**][**12 inches**][**16 inches**][**18 inches**].
3. Sound Curb: Curb with sound-absorbing insulation.
4. Hinged sub-base to provide access to damper or as cleanout for grease applications.
5. Burglar Bars: [**1/2-inch-**][**5/8-inch-**][**3/4-inch-**] thick steel bars welded in place to form **6-inch** squares.
6. Pitch Mounting: Manufacture curb for roof slope.
7. Metal Liner: Galvanized steel.
8. Mounting Pedestal: Galvanized steel with removable access panel.

2.15 VENTILATORS, CENTRIFUGAL - ROOF-MOUNTED UPBLAST OR SIDEWALL MOUNTED

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [Airmaster Fan; a brand of MAICO]
4. [American Coolair Corporation]
5. [Canarm Ltd.]
6. [Carnes Company]
7. [FloAire National]
8. [Greenheck Fan Corporation]
9. [JencoFan]
10. [Loren Cook Company]
11. [New York Blower Company (The)]

12. [PennBarry; division of Air System Components]
13. [Quietaire Inc.]
14. [Rupp Air Management Systems]
15. [S & P USA Ventilation Systems, LLC]
16. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:
1. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [Airmaster Fan; a brand of MAICO]
4. [American Coolair Corporation]
5. [Canarm Ltd.]
6. [Carnes Company]
7. [FloAire National]
8. [Greenheck Fan Corporation]
9. [JencoFan]
10. [Loren Cook Company]
11. [New York Blower Company (The)]
12. [PennBarry; division of Air System Components]
13. [Quietaire Inc.]
14. [Rupp Air Management Systems]
15. [S & P USA Ventilation Systems, LLC]
16. <Insert manufacturer's name>

C. Source Limitations: Obtain roof-mounted upblast or sidewall-mounted centrifugal ventilators from single manufacturer.

D. Standards:
1. Comply with UL 705.
2. Power ventilators for use with restaurant kitchen exhaust are to comply with UL 762.

E. Configuration: Centrifugal [roof upblast][roof upblast, kitchen grease hood][sidewall] ventilator.

F. Housing: Removable [spun-aluminum dome top and outlet baffle][extruded-aluminum rectangular top][galvanized-steel, mushroom-domed top][spun aluminum]; 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.
2. [Provide grease collector.]

G. Fan Wheels: Aluminum hub and wheel with backward-inclined blades[; spark-resistant construction classified in accordance with AMCA 99, Section 8,][Type A][Type B][Type C].

H. Belt Drives:
1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings; minimum ABMA 9, [**L10 of 100,000 hours**]<**Insert life**>.
4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through [**5**]<**Insert number**> hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than [**5**]<**Insert number**>

hp.

6. Fan and motor are isolated from exhaust airstream.

I. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted [**inside**][**outside**] fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, **1/2-inch** 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.
6. Mounting Pedestal: Galvanized steel with removable access panel.
7. Wall Mount Adapter: Attach wall-mounted fan to wall.
8. Restaurant Kitchen Exhaust: UL 762 listed for grease-laden air exhaust.

J. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; **1-1/2-inch-**thick, rigid, fiberglass insulation adhered to inside walls; and **1-1/2-inch** wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: [Self-flashing without a cant strip, with mounting flange][Built-in cant and mounting flange][Built-in raised cant and mounting flange][Manufactured to accommodate roof slope].

K. Prefabricated Kitchen Exhaust Roof Curbs: Galvanized steel; mitered and welded corners; ventilation openings on all sides to ventilate curb interstitial space. Size as required to suit roof opening and fan base.

1. Configuration: [Self-flashing without a cant strip, with mounting flange][Built-in cant and mounting flange][Built-in raised cant and mounting flange][manufactured to accommodate roof slope].
2. Overall Height: [**8 inches**][**9-1/2 inches**][**12 inches**][**16 inches**][**18 inches**].
3. Sound Curb: Curb with sound-absorbing insulation[**and galvanized metal liner**].
4. Hinged sub-base to provide access to damper or as cleanout for grease applications.
5. Burglar Bars: [**1/2-inch-**][**5/8-inch-**][**3/4-inch-**] thick steel bars welded in place to form **6-inch** squares.
6. Pitch Mounting: Manufacture curb for roof slope.
7. Metal Liner: Galvanized steel.
8. Mounting Pedestal: Galvanized steel with removable access panel.
9. Vented Curb: For kitchen exhaust; **12-inch-**high galvanized steel; unlined, with louvered vents in vertical sides.
10. NFPA 96 code requirements for commercial cooking operations.
11. Kitchen Hood Exhaust: UL 762 listed for grease-laden air.

2.16 FANS, PROPELLER - SIDEWALL MOUNTED

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [Airmaster Fan; a brand of MAICO]
4. [American Coolair Corporation]

5. [Canarm Ltd.]
6. [Carnes Company]
7. [JencoFan]
8. [Loren Cook Company]
9. [Moffitt Corporation]
10. [Peerless Blowers]
11. [PennBarry; division of Air System Components]
12. [Quietaire Inc.]
13. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:
1. [Acme Engineering & Manufacturing Corp.]
2. [Aerovent; a division of Twin City Fan Companies, Ltd.]
3. [Airmaster Fan; a brand of MAICO]
4. [American Coolair Corporation]
5. [Canarm Ltd.]
6. [Carnes Company]
7. [JencoFan]
8. [Loren Cook Company]
9. [Moffitt Corporation]
10. [Peerless Blowers]
11. [PennBarry; division of Air System Components]
12. [Quietaire Inc.]
13. <Insert manufacturer's name>

C. Source Limitations: Obtain sidewall-mounted propeller fans from single manufacturer.

D. Standards: Comply with UL 705.

E. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.

F. Fan Wheels: Formed-steel blades riveted to heavy-gauge steel spider bolted to cast-iron hub.

G. Fan Wheel: Replaceable, [**cast**][**extruded**]-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

H. Fan Drive, Direct: Direct-drive motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

I. Fan Drive, Belt:
1. Belt drive.
2. Resiliently mounted to housing.
3. Statically and dynamically balanced.
4. Selected for continuous operation at maximum-rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
5. Extend grease fitting to accessible location outside of unit.
6. Service Factor Based on Fan Motor Size: 1.4.
7. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
8. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
   a. Ball-Bearing Rating Life: ABMA 9, [**L10 of 100,000 hours**]<**Insert life**>.
9. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
10. Motor Pulleys: Adjustable pitch for use with motors through [**5**]<**insert value**> hp;

fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.

11. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.

J. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Dampers: Counterbalanced, parallel-blade, backdraft dampers factory set to close when fan stops.
3. Motorized Dampers: Parallel-blade dampers with electric actuator wired to close when fan stops.
4. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
5. Wall Sleeve: Galvanized steel to match fan and accessory size.
6. Weathershield Hood: Galvanized steel to match fan and accessory size.
7. Weathershield Front Guard: Galvanized steel with expanded metal screen.
8. Belt Guard: For motor mounted on outside of fan cabinet. Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; [**0.146-inch-**]<**Insert dimension**> thick, [**3/4-inch**]<**Insert dimension**> 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.

2.17 FANS, PROPELLER - ROOF-MOUNTED UPBLAST

A. Manufacturers: Subject to compliance with requirements, [provide products by the following][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. [Acme Engineering & Manufacturing Corp.]
2. [Airmaster Fan; a brand of MAICO]
3. [American Coolair Corporation]
4. [Canarm Ltd.]
5. [Carnes Company]
6. [Greenheck Fan Corporation]
7. [Hartzell Fan Incorporated]
8. [JencoFan]
9. [Loren Cook Company]
10. [Moffitt Corporation]
11. [New York Blower Company (The)]
12. [Northern Blower, Inc.]
13. [PennBarry; division of Air System Components]
14. [Quietaire Inc.]
15. [Rupp Air Management Systems]
16. [S & P USA Ventilation Systems, LLC]
17. <Insert manufacturer's name>

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:

1. [Acme Engineering & Manufacturing Corp.]
2. [Airmaster Fan; a brand of MAICO]

3. [American Coolair Corporation]
4. [Canarm Ltd.]
5. [Carnes Company]
6. [Greenheck Fan Corporation]
7. [Hartzell Fan Incorporated]
8. [JencoFan]
9. [Loren Cook Company]
10. [Moffitt Corporation]
11. [New York Blower Company (The)]
12. [Northern Blower, Inc.]
13. [PennBarry; division of Air System Components]
14. [Quietaire Inc.]
15. [Rupp Air Management Systems]
16. [S & P USA Ventilation Systems, LLC]
17. <Insert manufacturer's name>

C. Source Limitations: Obtain roof-mounted upblast propeller fans from single manufacturer.

D. Standards: Comply with UL 705.

E. Configuration: Upblast propeller ventilator.

F. Wind Band, Fan Housing, and Base: Reinforced and braced [**galvanized steel**][**aluminum**], containing [**galvanized-steel**][**aluminum**] butterfly dampers and rain trough, motor and drive assembly, and fan wheel.
   1. Damper Rods: Steel with [**bronze**][**nylon**] bearings.
   2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

G. Fan Wheel: Replaceable, [**cast**][**extruded**]-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades[**; spark-resistant construction classified in accordance with AMCA 99, Section 8,**][**Type A**][**Type B**][**Type C**].

H. Belt Drives:
   1. Resiliently mounted to housing.
   2. Weatherproof housing of same material as fan housing.
   3. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   4. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings.
   5. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   6. Motor Pulleys: Adjustable pitch for use with motors through [**5**]<**Insert number**> hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than [**5**]<**Insert number**> hp.
   7. Motor Mount: On outside of fan cabinet, adjustable base for belt tensioning.

I. Accessories:
   1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted [**inside**][**outside**] fan housing, factory wired through an internal aluminum conduit.
   2. Bird Screens: Removable, **1/2-inch** mesh, aluminum or brass wire.
   3. Inspection Door: Hinged.
   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.

6. Extended Lubrication Lines.
7. Belt Guard: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; [**0.146-inch-**]<**Insert dimension**> thick, [**3/4-inch**]<**Insert dimension**> 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.

J. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; **1-1/2-inch-**thick, rigid, fiberglass insulation adhered to inside walls; and **1-1/2-inch** wood nailer. Size as required to suit roof opening and fan base.
1. Configuration: [Self-flashing without a cant strip, with mounting flange][Built-in cant and mounting flange][Built-in raised cant and mounting flange].
2. Overall Height: [**8 inches**][**9-1/2 inches**][**12 inches**][**16 inches**][**18 inches**].
3. Sound Curb: Curb with sound-absorbing insulation.
4. Hinged sub-base to provide access to damper.
5. Burglar Bars: [**1/2-inch-**][**5/8-inch-**][**3/4-inch-**] thick steel bars welded in place to form **6-inch** squares.
6. Pitch Mounting: Manufacture curb for roof slope.
7. Metal Liner: Galvanized steel.
8. Mounting Pedestal: Galvanized steel with removable access panel.

2.18 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."

B. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive.

2.19 SOURCE QUALITY CONTROL

A. [AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.]

B. [AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.]

C. [AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.]

D. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Install fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, in accordance with manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:
1. Install floor-mounted fans on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Install roof-mounted fans on roof curbs or support steel. See Drawings for specific requirements.
3. Unit Support: Install fans level on structural curbs. Coordinate with duct connections. [Coordinate wall penetrations and flashing with wall construction.][Secure units to structural support with anchor bolts.]
4. Support duct-mounted and other hanging fans directly from the building structure,

using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

5. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
6. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Curb Support, Prefabricated: Rail-type wood support provided by fan manufacturer.

F. Unit Support: Install centrifugal fans level on structural [curbs][pilings]. Coordinate with duct connections. [Coordinate wall penetrations and flashing with wall construction.][Secure units to structural support with anchor bolts.]

G. Isolation Curb Support: Install centrifugal fans on isolation curbs, and install flexible duct connectors and vibration-isolation[**and seismic-control**] devices.

1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements in Section 230548.13 "Vibration Controls for HVAC."

H. Install units with adequate clearances for service and maintenance.

I. Label fans in accordance with requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.02 DUCTWORK CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Where installing ducts adjacent to fans, allow space for service and maintenance.

3.03 PIPING CONNECTIONS

A. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

B. Install heat tracing on all drain piping subject to freezing temperature and as indicated on Drawings. Furnish and install heat tracing in accordance with Section 230533 "Heat Tracing for HVAC Piping."

3.04 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch** high.

3.05 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.06 STARTUP SERVICE:

A. [Engage a factory-authorized service representative to perform][Perform] startup service.

1. Complete installation and startup checks in accordance with 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 ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
6. For belt-drive fans, 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.
7. Adjust belt tension.
8. Adjust damper linkages for proper damper operation.
9. Verify lubrication for bearings and other moving parts.
10. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
11. 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.
12. Shut unit down and reconnect automatic temperature-control operators.
13. Remove and replace malfunctioning units and retest as specified above.

3.07 ADJUSTING

A. Adjust damper linkages for proper damper operation.
B. Adjust belt tension.
C. Lubricate bearings.
D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.08 CLEANING

A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.09 FIELD QUALITY CONTROL

A. Testing Agency: [**Owner**][**Contractor**] will engage a qualified testing agency to perform tests and inspections.
B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
C. Perform tests and inspections[with the assistance of a factory-authorized service representative].
    1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
    2. Test and adjust controls and safeties.
    3. Fans and components will be considered defective if they do not pass tests and inspections.
    4. Prepare test and inspection reports.

3.10 DEMONSTRATION

A. [**Engage a factory-authorized service representative to train**][**Train**] Owner's maintenance personnel to adjust, operate, and maintain HVAC fans.

END OF SECTION

SECTION 233439
HIGH-VOLUME, LOW-SPEED FANS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes high-volume, low-speed fans.

1.03 DEFINITIONS

A. HVLS - High volume, low speed.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, furnished specialties, and accessories for each fan.
   2. Certified fan performance curves with system operating conditions indicated.
   3. Certified fan sound-power ratings.
   4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   5. Material thickness and finishes, including color charts.
   6. Fan speed controllers.

B. Sustainable Design Submittals:
   1. <Double click to insert sustainable design text for HVAC units.>
   2. <Double click to insert sustainable design text for minimum energy performance requirements.>
   3. <Double click to insert sustainable design text for thermal comfort requirements.>
   4. <Double click to insert sustainable design text for thermal comfort design requirements.>

C. Shop Drawings:
   1. Include plans, elevations, sections, and mounting details.
   2. Include details of equipment assemblies. Show dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

D. Delegated-Design Submittal: For each HVLS fan.
   1. Include design calculations and details for selecting product mounting components and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic forces required to select mounting components and seismic restraints.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Qualification Data:
   1. For Installer: Certificate from HVLS fan manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, controls, and accessories indicated and furnished for installation.

C. Seismic-Restraint Details:

1. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
2. 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 seismic events. Indicate association with vibration isolation devices.
3. Preapproval and Evaluation Documentation: By [an evaluation service member of ICC-ES] [Office of Statewide Health Planning and Development] [an agency acceptable to authorities having jurisdiction], showing maximum ratings of restraint items and the basis for approval (tests or calculations).

D. Field quality-control reports.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVLS fans to include in emergency, operation, and maintenance manuals.

1.07 QUALITY ASSURANCE

A. Manufacturer Qualifications: Provide certification that manufacturer complies with [**the most recent edition of ISO 9001**] <**Insert requirement**>.

B. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by HVLS fan manufacturer.
1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, controls, and accessories indicated and furnished for installation.
2. Installer certification shall be valid and current for duration of Project.
3. Retain copies of Installer certificates on-site and make available on request.
4. Each person assigned to Project shall have demonstrated past experience.
   a. Demonstrated past experience with products being installed for period within [**three**] [**five**] <**Insert number**> consecutive years before time of bid.
   b. Demonstrated past experience on [**five**] <**Insert number**> projects of similar complexity, scope, and value.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in a clean and dry place.

B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.

C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.

D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.

E. Replace installed products damaged during construction.

1.09 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of fans that fail in materials or workmanship within specified warranty period.
1. Warranty Period:
   a. For Motor, Including Controls: [**Five**] [**Seven**] [**10**] <**Insert number**> year(s) from date of Substantial Completion.

b. For Parts, Including Blades and Hub: [**Five**] [**Seven**] [**10**] <**Insert number**> year(s) from date of Substantial Completion.
c. For Labor: [**One**] [**Two**] <**Insert number**> year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

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. UL Compliance: Listed and labeled to UL 507.
C. CSA Compliance: Listed and labeled to CSA C22.2, No. 113.
D. Comply with NFPA 13 requirements for HVLS fans.
E. AMCA Compliance:
1. Test HVLS fans according to AMCA 230.
2. Certify HVLS fan performance according to AMCA 211.
F. Performance Data: Comply with ANSI 230 test procedure standard, based on five rating points: 20-, 40-, 60-, 80-, and 100-percent of maximum speed. Comply with AMCA 211 for publication of performance data.
G. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design HVLS ceiling fans.
H. Seismic Performance: HVLS ceiling fans shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] <**Insert requirement**>.
1. The term "withstand" means "the HVLS fans will remain in place without separation of any parts when subjected to the seismic forces specified[**and the units will be fully operational after the seismic event**]."
2. Component Importance Factor: [**1.5**] [**1.0**].
3. <Insert requirements for Component Amplification Factor and Component Response Modification Factor>.

2.02 CAPACITIES AND CHARACTERISTICS

A. Fan:
1. Type: HVLS [Upflow] [Downflow] [Selectable].
2. Number of Fan Blades: <**Insert number**>.
3. Fan Diameter: <**Insert value**> feet.
4. Maximum Fan Speed: <**Insert rpm**>.
5. Fan Airflow at AMCA Rating Points cfm:
a. Airflow at 20 Percent: <**Insert value**>.
b. Airflow at 40 Percent: <**Insert value**>.
c. Airflow at 60 Percent: <**Insert value**>.
d. Airflow at 80 Percent: <**Insert value**>.
e. Airflow at 100 Percent: <**Insert value**>.
6. Fan Discharge Sound Power at Maximum Speed, dB:
a. 1st Octave: <**Insert value**>.
b. 2nd Octave: <**Insert value**>.
c. 3rd Octave: <**Insert value**>.
d. 4th Octave: <**Insert value**>.
e. 5th Octave: <**Insert value**>.
f. 6th Octave: <**Insert value**>.
g. 7th Octave: <**Insert value**>.
h. 8th Octave: <**Insert value**>.
B. Motor:

1. Size: <Insert horsepower>.
2. Speed: <**Insert rpm**>.
3. Volts: [**120**] [**208**] [**230**] [**277**] [**460**] <**Insert value**> V.
4. Phase: [Single] [Three] <Insert number>.
5. Hertz: [**60**] <**Insert number**> Hz.
6. Full-Load Amperes: <**Insert value**> A.
7. Minimum Circuit Ampacity: <**Insert value**> A.
8. Maximum Overcurrent Protection: <**Insert amperage**> A.

2.03 MANUFACTURERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Source Limitations: Obtain HVLS fans from single source from single manufacturer.

2.04 HIGH-VOLUME, LOW-SPEED FANS

A. Description: Factory-assembled and -tested horizontal, non-ducted fan unit, consisting of large-diameter blade set, direct-drive electric motor, with [**speed-reducing gearbox**] [**variable-speed motor controller**].

1. Provide fan designed to circulate large air volume, vertically, at low velocity.
2. Maximum Operating Temperature: [**122**] [**140**] <**Insert value**> deg F.
3. Frame:
   a. Material: [Aluminum] [Galvanized steel] [Stainless steel] <Insert metal>.
      1) Finish: [Paint] [Powdercoat] [Thermoset, polyester powder paint] [Anodized] <Insert finish>.
4. Diameter: [**8**] [**10**] [**12**] [**14**] [**16**] [**18**] [**20**] [**24**] <Insert diameter> feet.
5. Blades: Airfoil type.
   a. Quantity: [**3**] <**Insert number**>.
   b. Material: [Aluminum] <Insert material>.
      1) Blade Finish: [Anodized] <Insert finish>.
6. Motor: [Squirrel cage], [integral to fan frame] [totally enclosed fan cooled] [ODP] [explosion proof] <Insert motor enclosure class>.
7. Wiring and Controls Enclosure:
   a. NEMA 250, [Class 1] [Class 4] [Class 4X] <Insert NEMA enclosure class>.
   b. Material: [Aluminum] [Galvanized steel] [Stainless steel] <Insert metal>.
      1) Enclosure Finish: [Paint] [Powdercoat] [Thermoset] [Polyester powder paint] [Anodized] [Polished] <Insert finish>.
   c. Grounded.
8. Controls: Provide [wall-mounted keypad] <Insert controlling device>.
   a. Provide [fixed] [automatic] [manual] [variable speed motor controller] [Insert speed control component here] speed control.
9. Maximum Sound Power Level: <**Insert value**> dBA.
10. Standard Mounting Bracket: Steel beam/steel angle.
11. Mounting Bracket: [Large beam] [Solid beam] [Z-purlin] <Insert mounting bracket type>.
12. Accessories:
    a. Mounting extension tube.
    b. <Insert accessory option here>.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine conditions for compliance with requirements for installation tolerances and other conditions affecting HVLS fan performance, maintenance, and operations.

1. Fan locations indicated on Drawings are approximate. Determine exact locations before roughing-in for mounting, control, and electrical connections.

B. Examine roughing-in for mounting location, anchor-bolt sizes, and locations, to verify actual locations for mounting connections before installation of fan.

C. Examine areas for suitable conditions where fan will be installed.

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

3.02 INSTALLATION OF HIGH-VOLUME LOW-SPEED FANS

A. Install fan according to manufacturer's published instructions.

B. Comply with NECA 1 and NFPA 70.

C. Comply with NFPA 13 for installation of HVLS fans and maximum allowable fan diameter. Center HVLS fans between four adjacent sprinklers. Minimum vertical clearance from HVLS fan to sprinkler deflector is 3 feet.

D. Comply with NFPA 72 and interlock HVLS fans to shut down upon receiving an alarm from fire alarm system.

E. Equipment Mounting:

1. Anchor fan to building structure [with manufacturer's recommended mounting bracket] [as shown in approved delegated design] for installed condition.
2. Consult a licensed professional structural engineer for mounting methods and approval for mounting to the structure. Structure must be able to withstand the torque and forces generated by the fan.
3. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
4. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
5. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

F. Install unit to permit access for maintenance.

G. Install parts and accessories shipped loose.

3.03 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

E. Install power wiring to field-mounted electrical devices, furnished by fan manufacturer, but not factory mounted.

3.04 CONTROL CONNECTIONS

A. Connect control wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

C. Connect control interlock wiring between HVLS fan and other equipment to provide a complete and functioning system.

D. Connect control wiring between fan unit control interface and control system to provide remote control and monitoring.
E. Install control devices furnished by manufacturer, but not factory mounted.
F. Install control wiring to field-mounted control devices, furnished by fan manufacturer, but not factory mounted.
G. Protect installed units from damage caused by other work.

3.05 FIELD QUALITY CONTROL

A. Testing Agency, Owner Engaged: Owner will engage a qualified testing agency to perform tests and inspections.
B. Testing Agency, Contractor Engaged: 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[with the assistance of a factory-authorized service representative]:
    1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
    2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
E. Fan or components will be considered defective if fan or components do not pass tests and inspections.
F. Prepare and submit test and inspection reports.

3.06 STARTUP SERVICE

A. [Engage a factory-authorized service representative to perform] [Perform] startup service.
    1. Complete installation and startup checks according to manufacturer's written instructions.
    2. Verify that fan is secure on mountings and supporting devices and that connections to electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers and switches.
    3. Verify proper motor rotation direction and free fan rotation.
    4. Check bearing [**and gearbox**] lubrication.
    5. Verify proper fan rotation. [Set rotation selector to blow vertically downward during heating season, and vertically upward during cooling season.]

3.07 ADJUSTING

A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.08 CLEANING

A. Clean equipment externally; remove coatings applied for protection during shipping and storage, foreign material, and oily residue according to manufacturer's written instructions. Following manufacturer's cleaning procedures, and clean with manufacturer-recommended cleaning products.

3.09 DEMONSTRATION

A. [**Engage a factory-authorized service representative to train**] [**Train**] Owner's maintenance personnel to adjust, operate, and maintain HVLS fans.
B. Video training sessions, and provide electronic copy of video to Owner.

END OF SECTION

SECTION 233600
AIR TERMINAL UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Modulating, single-duct air terminal units.
   2. Casing liner.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For air terminal units.
   1. Include plans, elevations, sections, and mounting details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. Instructions for resetting minimum and maximum air volumes.
      b. Instructions for adjusting software set points.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a Qualified Electrical Testing Laboratory, and marked for intended location and application.

B. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.02 MANUFACTURERS

A. Trane Model VCWF as scheduled on drawings.

B. Approved equals must meet the specification including all scheduled performance.

2.03 MODULATING, SINGLE-DUCT AIR TERMINAL UNITS

A. Products:
   1. Trane Model VCWF as scheduled on drawings.
   2. Approved equals must meet the specification including all scheduled performance.

B. Description: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: Minimum 0.034-inch-thick galvanized steel.
   1. Casing Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass duct liner.
   2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
   3. Air Outlet: S-slip and drive connections**,** size matching inlet size.
   4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.

E. Velocity Sensors: Multipoint array with velocity inlet sensors.

F. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.08 inch. Include manual air vent and drain valve. Provide hydronic heating coils for air terminal units scheduled on Drawings.

G. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
   1. Electric Damper Actuator: 24 V, powered open, fail last-position.
   2. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.
   3. Terminal Unit Controller: Pressure-independent, variable-air-volume (VAV) controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
      a. Occupied and unoccupied operating mode.
      b. Remote reset of airflow or temperature set points.
      c. Adjusting and monitoring with portable terminal.
      d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
   4. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

H. Controls:
   1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.
   2. System-powered, wall-mounted thermostat.

2.04 CASING LINER

A. Casing Liner: Fibrous-glass duct liner, complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   1. Minimum Thickness: 1/2 inch.
      a. Maximum Thermal Conductivity:
         1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
   2. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.

2.05 SOURCE QUALITY CONTROL

A. AHRI 880: Test and rate assembled air terminal units in accordance with AHRI 880.

B. Water Coils: Factory pressure test to 300 psig in accordance with AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" and Section 233113 "Metal Ducts" for hangers and supports.

B. Install air terminal units according to NFPA 90A.

C. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

D. Install wall-mounted thermostats.

3.02 PIPING CONNECTIONS

A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

B. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," and connect heating coils to supply piping with shutoff valve, strainer, control valve, and union or flange; and to return piping with balancing valve and union or flange.

3.03 DUCTWORK CONNECTIONS

A. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.

B. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.04 ELECTRICAL CONNECTIONS

A. Install field power to each air terminal unit electrical power connection. Coordinate with air terminal unit manufacturer and installers.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

3.05 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.06 IDENTIFICATION

A. Label each air terminal unit with drawing designation, nominal airflow, maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.07 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks in accordance with 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.

3.08 ADJUSTING

A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air terminal unit testing, adjusting, and balancing.

3.09 FIELD QUALITY CONTROL

A. Perform the following 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. Air terminal unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION

SECTION 233713.13
AIR DIFFUSERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Rectangular and square ceiling diffusers.
   2. Perforated diffusers.

B. Related Requirements:
   1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.
   2. Section 233713.23 "Air Registers and Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
   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 Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.01 RECTANGULAR AND SQUARE CEILING DIFFUSERS

A. Products:
   1. Price Industries Model SCD or approved equal.

B. Material: Steel.

C. Finish: Baked enamel, color selected by Architect.

D. Face Size: 24 by 24 inches.

E. Face Style: Four cone.

F. Mounting: T-bar.

G. Pattern: Fixed.

2.02 PERFORATED DIFFUSERS

A. Products:
   1. Price Industries Model PDDR or approved equal.

B. Material: Steel backpan and pattern controllers, with steel face.

C. Finish: Baked enamel, color selected by Architect.

D. Face Size: 24 by 24 inches.

E. Duct Inlet: Round.

F. Face Style: Flush.

G. Mounting: T-bar.

2.03 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas where diffusers are 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.

3.02 INSTALLATION

A. Install diffusers level and plumb.

B. 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 practical. 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.

C. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.03 ADJUSTING

A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 233713.23
REGISTERS AND GRILLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Adjustable blade grilles.
   2. Fixed face grilles and registers.
   3. Fixed face raised floor grilles.
   4. Linear bar grilles.

B. Related Requirements:
   1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.
   2. Section 233713.13 "Air Diffusers" for various types of air diffusers.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
   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. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.01 GRILLES

A. Adjustable Blade Face Grille:
   1. Products:
      a. Price Industries Model 510 or approved equal.
   2. Material: Steel.
   3. Finish: Baked enamel, color selected by Architect.
   4. Face Blade Arrangement: spaced 3/4 inch apart.
   5. Rear-Blade Arrangement: spaced 3/4 inch apart.
   6. Frame: 1-1/4 inches wide.

B. Fixed Face Grille:
   1. Products:
      a. Price Industries Model 530 or approved equal.
   2. Material: Steel.
   3. Finish: Baked enamel, color selected by Architect.
   4. Face Blade Arrangement: Horizontal; spaced 3/4 inch apart.
   5. Frame: 1-1/4 inches wide.

C. Fixed Face Sidewall Register:
   1. Products:
      a. Price Industries Model 630DAL or approved equal.
   2. Material: Aluminum.
   3. Finish: Baked enamel, white.
   4. Damper material: Aluminum.
   5. Frame: 1-1/4 inches wide.

D. Fixed Face Grille for Raised Floor:
   1. Products:
      a. Tate Access Floors, Inc., Model DirectAire Al-24 or approved equal.

2. Material: Aluminum.
3. Finish: Smoke Grey ainti-static powder coat.
4. Damper material: Aluminum.
5. Frame: As required for installation in raised floor system.

E. Linear Bar Grille:
1. Products:
a. Price Industries Model LBMH or approved equal.
2. Material: Aluminum.
3. Finish: Baked enamel, color selected by Architect from manufacturer’s full color and finish range.
4. Face Blade Arrangement: Parallel to long dimension; spaced 1/4 inch apart. 15 degrees deflection.
5. Frame: 1000, 1inch wide.
6. Mounting: Surface mount with spring clips.

2.02 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate registers and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas where registers and grilles are 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.

3.02 INSTALLATION

A. Install registers and grilles level and plumb.
B. Outlets and Inlets Locations: 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 practical. 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.
C. Install registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.03 ADJUSTING

A. After installation, adjust registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 233723
HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Hooded ventilators.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product
B. Shop Drawings: For gravity ventilators.
   1. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.
   2. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.
   3. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

1.04 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.01 HOODED VENTILATORS

A. Description: Hooded rectangular and round-domed vent for intake, relief, or exhaust as indicated on drawings.
B. Source Limitations: Obtain hooded ventilators from single manufacturer.
C. Construction:
   1. Material, Aluminum: Thickness required to comply with structural performance requirements, but not less than 0.063-inch-thick base and 0.050-inch-thick hood; suitably reinforced.
   2. Bird Screening: Aluminum, 1/2-inch-square mesh or flattened, expanded aluminum, 3/4-inch diamond mesh wire.
D. Roof Curbs: Aluminum sheet with mitered corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.
   1. Configuration: As required for roof type and slope.
   2. Overall Height: 12 inches.

2.02 SOURCE QUALITY CONTROL

A. AMCA Certification for Hooded Ventilators: Test, rate, and label gravity ventilators in accordance with AMCA 511.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.
B. Secure gravity ventilators to roof curbs with zinc-plated hardware. Use concealed anchorages where possible.
C. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Section 079200 "Joint Sealants" for sealants applied during installation.
D. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with dissimilar metals.

E. Refer to Section 077200 "Roof Accessories" for flashing and counterflashing of roof curbs.

END OF SECTION

SECTION 235416.13
GAS-FIRED FURNACES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Gas-fired furnaces, noncondensing.
   2. Gas-fired furnaces, condensing.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Sustainable Design Submittals:
   1. <Double click to insert sustainable design text for HVAC units.>
   2. <Double click to insert sustainable design text for adhesives.>

C. Shop Drawings:
   1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Include diagrams for power, signal, and control wiring.

1.03 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each furnace to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. Furnace and accessories complete with controls.
      b. Air filter.
      c. Air cleaner.
      d. UV germicidal light.
      e. Humidifier.
      f. Ventilation heat exchanger.
      g. Refrigeration components.

1.05 MAINTENANCE MATERIAL SUBMITTALS

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. Disposable Air Filters: Furnish [**two**] <**Insert number**> complete sets.
   2. Disposable Air-Cleaner Media: Furnish [**one**] <**Insert number**> complete set(s).
   3. Fan Belts: Furnish [**one**] <**Insert number**> set(s) for each furnace fan.
   4. Disposable Humidifier Media: Furnish [**one**] <**Insert number**> set(s).

1.06 QUALITY ASSURANCE

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

B. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

C. Comply with NFPA 70.

1.07 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace the following components of furnaces that fail in materials or workmanship within specified warranty period:
   1. Warranty Period, Commencing on Date of Substantial Completion:
      a. Furnace Heat Exchanger: [**10 years**] [**20 years**] [**Lifetime**] <**Insert value**>.
      b. Integrated Ignition and Blower Control Circuit Board: [**Five years**] <**Insert value**>.
      c. Draft-Inducer Motor: [**Five years**] <**Insert value**>.
      d. Refrigeration Compressors: [**10 years**] [**Lifetime**] <**Insert value**>.
      e. Evaporator and Condenser Coils: [**Five years**] <**Insert value**>.
      f. <Insert components requiring extended warranty>.

PART 2 - PRODUCTS

2.01 ASSEMBLY DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency, and marked for intended location and application.

B. General Requirements for Noncondensing Gas-Fired Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.

2.02 GAS-FIRED FURNACES, NONCONDENSING

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Cabinet: [Steel] [Galvanized steel].
   1. Cabinet interior around heat exchanger shall be factory-installed insulation.
   2. Lift-out panels shall expose burners and all other items requiring access for maintenance.
   3. Factory paint external cabinets in manufacturer's standard color.
   4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Fan: Centrifugal, factory balanced, resilient mounted, [direct drive] [belt drive] [direct or belt drive] [drive type indicated on Drawings].
   1. Fan Motors: Comply with requirements in Section 230500 "Common Work Results for HVAC."
   2. Special Motor Features, Single Speed: Single speed, premium efficiency, as defined in Section 230500 "Common Work Results for HVAC," and with internal thermal protection and permanent lubrication.
   3. Special Motor Features, Multispeed: Multitapped, multispeed with internal thermal protection and permanent lubrication.
   4. Special Motor Features, ECM: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.

D. Type of Gas: [**Natural**] [**Propane**].

E. Heat Exchanger: [**Aluminized**] [**Stainless**] steel.

F. Burner:
   1. Gas Valve: 100 percent safety [**two-stage**] [**modulating**] main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
   2. Ignition: Electric pilot ignition, with hot-surface igniter or electric spark ignition.

G. Gas-Burner Safety Controls:
   1. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
   2. Flame Rollout Switch: Installed on burner box; prevents burner operation.

3. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.

H. Combustion-Air Inducer: Centrifugal fan with thermally protected motor and sleeve bearings prepurges heat exchanger and vents combustion products; pressure switch prevents furnace operation if combustion-air inlet or flue outlet is blocked.

I. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; and adjustable fan-on and fan-off timing; terminals for connection to accessories.

J. Vent Materials: Comply with requirements in Section 235123 "Gas Vents" for Type B metal vents.

K. Capacities and Characteristics:

1. Airflow Configuration: [**Upflow**] [**Counterflow**] [**Horizontal**].
2. Gas:
   a. Type: [Natural] [Propane].
   b. Venting Type: [Power venter][with combustion-air intake].
   c. Minimum Efficiency AFUE: <**Insert number**> percent.
   d. Minimum Thermal Efficiency: <**Insert number**> percent.
   e. Minimum Combustion Efficiency: <**Insert number**> percent.
   f. Input: <Insert **MBh**>.
   g. Heat Output: <**Insert MBh**>.
   h. Gas Connection Size: <**Insert NPS**>.
   i. Draft-Inducer Motor:
      1) Size: <Insert horsepower>.
      2) Speed: <**Insert rpm**>.
   j. Combustion-Air Inlet Size: <**Insert inches**>.
   k. Combustion-Air Inlet Material: [**Galvanized steel**] [**Stainless steel**] [**PVC**].
   l. Heat-Exchanger Condensate Drain Size: <**Insert NPS**>.
   m. Vent Size: <Insert **inches**>.
3. Fan:
   a. Airflow: <Insert **cfm**>.
   b. External Static Pressure: <**Insert inches wg**>.
   c. Motor:
      1) Size: <Insert horsepower>.
      2) Speed: <**Insert rpm**>.
   d. Volts: <Insert value>.
   e. Phase: <Insert value>.
   f. Hertz: <Insert value>.
   g. Full-Load Amperes: <**Insert value**>.
   h. Minimum Circuit Ampacity: <**Insert value**>.
   i. Maximum Overcurrent Protection: <**Insert amperage**>.
4. Furnace Electrical Connection:
   a. Volts: <Insert value>.
   b. Phase: <Insert value>.
   c. Hertz: <Insert value>.
   d. Full-Load Amperes: <**Insert value**>.
   e. Minimum Circuit Ampacity: <**Insert value**>.
   f. Maximum Overcurrent Protection: <**Insert amperage**>.

2.03 GAS-FIRED FURNACES, CONDENSING

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Cabinet: [Steel] [Galvanized steel].

1. Cabinet interior around heat exchanger shall be factory-installed insulation.
2. Lift-out panels shall expose burners and all other items requiring access for maintenance.
3. Factory paint external cabinets in manufacturer's standard color.
4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Fan: Centrifugal, factory balanced, resilient mounted, direct drive.
1. Fan Motors: Comply with requirements in Section 230500 "Common Work Results for HVAC."
2. Special Motor Features, Single Speed: Single speed, premium efficiency, as defined in Section 230500 "Common Work Results for HVAC," and with internal thermal protection and permanent lubrication.
3. Special Motor Features, Multispeed: Multitapped, multispeed with internal thermal protection and permanent lubrication.
4. Special Motor Features, ECM: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.

D. Type of Gas: [**Natural**] [**Propane**].

E. Heat Exchanger:
1. Primary: [**Aluminized**] [**Stainless**] steel.
2. Secondary: [Polyethylene-coated] [Stainless] steel.

F. Burner:
1. Gas Valve: 100 percent safety [**two-stage**] [**modulating**] main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
2. Ignition: Electric pilot ignition, with hot-surface igniter or electric spark ignition.

G. Gas-Burner Safety Controls:
1. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
2. Flame Rollout Switch: Installed on burner box; prevents burner operation.
3. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.

H. Combustion-Air Inducer: Centrifugal fan with thermally protected motor and sleeve bearings prepurges heat exchanger and vents combustion products; pressure switch prevents furnace operation if combustion-air inlet or flue outlet is blocked.

I. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; adjustable fan-on and fan-off timing; terminals for connection to accessories[**; diagnostic light with viewport**].

J. Accessories:
1. Combination Combustion-Air Intake and Vent: PVC plastic fitting to combine combustion-air inlet and vent through [**outside wall**] [**roof**].
2. CPVC Plastic Vent Materials:
   a. CPVC Plastic Pipe: Schedule 40, complying with ASTM F441/F441M.
   b. CPVC Plastic Fittings: Schedule 40, complying with ASTM F438, socket type.
   c. CPVC Solvent Cement: ASTM F493.
      1) <Double click to insert sustainable design text for solvent cement.>
      2) <Double click to insert sustainable design text for adhesive.>
3. PVC Plastic Vent Materials:
   a. PVC Plastic Pipe: Schedule 40, complying with ASTM D1785.
   b. PVC Plastic Fittings: Schedule 40, complying with ASTM D2466, socket type.

c. PVC Solvent Cement: ASTM D2564.
1) <Double click to insert sustainable design text for adhesive primer.>
2) <Double click to insert sustainable design text for solvent cement.>
3) <Double click to insert sustainable design text for adhesive primer.>
4) <Double click to insert sustainable design text for adhesive.>

K. Capacities and Characteristics:
1. Airflow Configuration: [**Upflow**] [**Counterflow**] [**Horizontal**].
2. Gas:
a. Type: [Natural] [Propane].
b. Venting Type: [Power venter] [Power venter with combustion-air intake].
c. Minimum Efficiency AFUE: <**Insert number**> percent.
d. Minimum Thermal Efficiency: <**Insert number**> percent.
e. Minimum Combustion Efficiency: <**Insert number**> percent.
f. Input: <Insert **MBh**>.
g. Heat Output: <**Insert MBh**>.
h. Gas Connection Size: <**Insert NPS**>.
i. Draft-Inducer Motor:
1) Size: <Insert horsepower>.
2) Speed: <**Insert rpm**>.
j. Combustion-Air Inlet Size: <**Insert inches**>.
k. Combustion-Air Inlet Material: [**CPVC**] [**PVC**].
l. Heat-Exchanger Condensate Drain Size: <**Insert NPS**>.
m. Vent Size: <Insert **inches**>.
n. Vent Material: [**CPVC**] [**PVC**].
3. Fan:
a. Airflow: <Insert **cfm**>.
b. External Static Pressure: <**Insert inches wg**>.
c. Motor:
1) Size: <Insert horsepower>.
2) Speed: <**Insert rpm**>.
d. Volts: <Insert value>.
e. Phase: <Insert value>.
f. Hertz: <Insert value>.
g. Full-Load Amperes: <**Insert value**>.
h. Minimum Circuit Ampacity: <**Insert value**>.
i. Maximum Overcurrent Protection: <**Insert amperage**>.
4. Furnace Electrical Connection:
a. Volts: <Insert value>.
b. Phase: <Insert value>.
c. Hertz: <Insert value>.
d. Full-Load Amperes: <**Insert value**>.
e. Minimum Circuit Ampacity: <**Insert value**>.
f. Maximum Overcurrent Protection: <**Insert amperage**>.

2.04 THERMOSTATS AND HUMIDISTATS

A. Controls shall comply with requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."

B. Solid-State Thermostat: [**Wall-mounted**] [**Freestanding**] [**Wireless**], programmable, microprocessor-based unit with [**automatic**] [**manual**] switching from heating to cooling, preferential rate control, seven-day programmability with minimum of four temperature

presets per day, [**vacation mode,**]and battery backup protection against power failure for program settings.

C. Single-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounted unit with fan on-automatic selector.

D. Two-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounted unit with fan on-automatic selector.

E. Heating-Only Thermostat: [**Single**] [**Two**]-stage, wall-mounted unit with fan on-automatic selector.

F. Solid-State, Combination Thermostat and Humidistat: [**Wall-mounted**] [**Freestanding**] [**Wireless**], programmable, microprocessor-based unit with automatic switching from heating to cooling and humidifying to dehumidifying, preferential rate control, seven-day programmability with minimum of four temperature presets per day, [**vacation mode,**]and battery backup protection against power failure for program settings.

G. Humidistat: Adjustable, [**wall**] [**duct**]-mounted unit.

H. Control Wiring: Balanced twisted-pair cabling complying with requirements for Category 5e in [Section 260523 "Control-Voltage Electrical Power Cables."] [Section 271513 "Communications Copper Horizontal Cabling."]

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: [Unshielded twisted pairs (UTP)] [Shielded twisted pairs (FTP)] [Screened twisted pairs (F/UTP)] [Screened and shielded twisted pairs (F/FTP)], No. 24 AWG, 100 ohms, four pair.
3. Cable Jacket Color: [**Blue**] <**Insert color**>.

2.05 AIR FILTERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Washable Filters: 1-inch-thick urethane pad.

C. Disposable Filters: [**1-inch-**] <Insert dimension> thick fiberglass media[with ASHRAE 52.2 MERV rating of 6 or higher,] in sheet metal frame.

D. Charged Media Air Filters: Sheet metal housing arranged to be ducted in return-air duct connection to furnace; generates electrostatic charge; MERV 10 rating.

E. HEPA Air Filter Units: Sheet metal housing with fan arranged to be ducted to return-air duct connection to furnace, with activated carbon prefilter[**, carbon VOC,**] and high-efficiency particulate air (HEPA) disposable filter. HEPA shall be as follows:

1. Standard: UL 586.
2. Rating: ASHRAE 52.2, 99.97 percent efficiency to 0.30-micrometer particle size.

2.06 AIR CLEANERS

A. Electronic Air Cleaners: Packaged system, including sheet metal housing, prefilter, power supply, and automatic control device, arranged for mounting in return-air duct at furnace; equip with on-off and test switches and pilot light.

1. Standard: UL 586.
2. Rating: ASHRAE 52.2, particle size to 0.01 micrometer.
3. Static Pressure Drop: Maximum 0.14-inch wg at 300-fpm air velocity.

B. Capacities and Characteristics:

1. Volts: <Insert value>.
2. Phase: <Insert value>.
3. Hertz: <Insert value>.
4. Minimum Circuit Ampacity: <**Insert value**>.
5. Maximum Overcurrent Protection: <**Insert amperage**>.

2.07 UV GERMICIDAL LIGHTS

A. Description: Lighting unit in metal housing arranged for installation in supply-air duct and controlled to cycle on and off with furnace fan, with [**one**] [**two**] 75-W UV-light bulb(s).

2.08 HUMIDIFIERS

A. Minimum capacity rating indicated according to AHRI 610.

B. Media-wheel bypass type with bypass damper and motor-driven media wheel in reservoir with float-valve level control; arranged for mounting on return duct or plenum with bypass connection to supply duct.

C. Wetted-pad, continuous-drain, bypass type with bypass damper and water-flow control orifice; arranged for mounting on return duct or plenum with bypass connection to supply duct.

D. Fan-powered, wetted-pad, continuous-drain type with water-flow control orifice and motor; arranged for mounting on duct or plenum.

E. Pumped, fan-powered, wetted-pad type with reservoir-level control and pump and fan motors; arranged for mounting on duct or plenum.

F. Steam type with electric heating element in stainless-steel reservoir with float-valve level control; arranged for attachment to duct or plenum and for control by humidistat.

G. Comply with applicable requirements in ASHRAE 62.1.

H. Capacities and Characteristics:

1. Type: [Steam] [Media wheel] [Wetted pad with reservoir] [Wetted pad with continuous drain] [Wetted-pad bypass].
2. Steam Capacity: <**Insert lb/h**>.
3. Water Connection Size: <**Insert NPS**>.
4. Drain Connection Size: <**Insert NPS**>.
5. Volts: <Insert value>.
6. Phase: <Insert value>.
7. Hertz: <Insert value>.
8. Minimum Circuit Ampacity: <**Insert value**>.
9. Maximum Overcurrent Protection: <**Insert amperage**>.

2.09 VENTILATION AIR HEAT EXCHANGERS

A. Cabinet: Steel, with factory-installed interior insulation and manufacturer's standard factory finish. Fabricate with space for piping and electrical conduits.

B. Heat-Recovery Device: Fixed-plate, polypropylene copolymer (high-density plastic) heat-exchanger plates evenly spaced and sealed and arranged for counter airflow.

C. Supply and Exhaust Fans: Forward curved centrifugal with direct drive. Motors comply with requirements in Section 230500 "Common Work Results for HVAC."

D. Filters: 1-inch-thick disposable type[**with ASHRAE 52.2 MERV rating of 6 or higher**], in galvanized-steel frame, mounted upstream of unit in both supply and exhaust airstreams.

E. Wiring: Wire motors and controls so only external connections are required during installation.

2.10 REFRIGERATION COMPONENTS

A. General Refrigeration Component Requirements:

1. Refrigeration compressor, coils, and specialties shall be designed to operate with CFC-free refrigerants.
2. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IES 90.1.

B. Refrigerant Coil: Copper tubes mechanically expanded into aluminum fins. Comply with AHRI 210/240. Match size with furnace. Include condensate drain pan with accessible drain outlet[**complying with ASHRAE 62.1**].

1. Refrigerant Coil Enclosure: Steel, matching furnace and evaporator coil, with access panel and flanges for integral mounting at or on furnace cabinet and galvanized sheet metal drain pan coated with black asphaltic base paint.

C. Refrigerant Line Kits: Annealed-copper suction and liquid lines factory cleaned, dried, pressurized with nitrogen, sealed, and with suction line insulated. Provide in standard lengths for installation without joints, except at equipment connections.
1. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534/C534M, Type I, [**1/2 inch**] [**1 inch**] <**Insert dimension**> thick.

D. Refrigerant Piping: Comply with requirements in Section 232300 "Refrigerant Piping."

E. Air-Cooled Compressor-Condenser Unit:
1. Casing: Steel, finished with baked enamel, 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.
2. Compressor: Hermetically sealed [**reciprocating**] [**or**] [**scroll**] type.
a. Crankcase heater.
b. [**Restrained vibration**] [**Vibration**] isolation mounts for compressor.
c. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
d. Two-speed compressor motors shall have manual-reset high-pressure switch and automatic-reset low-pressure switch.
e. Refrigerant Charge: [**R-407C**] [**R-410A**] <**Insert type**>.
f. Refrigerant: R-407C or R-410A.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with liquid subcooler.
4. Heat-Pump Components: Reversing valve and low-temperature air cut-off thermostat.
5. Fan: Aluminum-propeller type, directly connected to motor.
6. Motor: Permanently lubricated, with integral thermal-overload protection.
7. Low Ambient Kit: Permits operation down to 45 deg F.
8. Mounting Base: Polyethylene.

F. Capacities and Characteristics:
1. Refrigerant Coil:
a. Total Cooling Capacity: <**Insert Btu/h**>.
b. Sensible Cooling Capacity: <**Insert Btu/h**>.
c. Heating Capacity: <**Insert Btu/h**>.
d. Maximum Air Pressure Drop: <**Insert inches wg**>.
e. Condensate Drain Size: <**Insert NPS**>.
2. Compressor-Condenser Unit:
a. Cooling Energy Efficiency[**(EER)**] [**(SEER)**]: <**Insert value**>.
b. Heating Coefficient of Performance: <**Insert value**>.
c. Volts: <Insert value>.
d. Phase: <Insert value>.
e. Hertz: <Insert value>.
f. Full-Load Amperes: <**Insert value**>.
g. Minimum Circuit Ampacity: <**Insert value**>.
h. Maximum Overcurrent Protection: <**Insert amperage**>.
i. Fan Motor Full-Load Amperes: <**Insert value**>.
j. Compressor Running-Load Amperes: <**Insert value**>.
k. Compressor Motor Full-Load Amperes: <**Insert value**>.

PART 3 - EXECUTION

3.01 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 factory-installed insulation before furnace installation. Reject units that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for gas[**and refrigerant**] piping systems to verify actual locations of piping connections before equipment installation.

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

3.02 INSTALLATION

A. Install gas-fired furnaces and associated fuel and vent features and systems according to NFPA 54.

B. Suspended Units: Suspend from structure using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

1. Install seismic restraints to limit movement of furnace by resisting code-required seismic acceleration.

C. Base-Mounted Units: Secure units to substrate. Provide optional bottom closure base if required by installation conditions.

1. Anchor furnace to substrate to resist code-required seismic acceleration.

D. Controls: Install thermostats and humidistats at mounting height of 60 inches above floor.

E. Wiring Method: Install control wiring in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal control wiring except in unfinished spaces.

F. Install ground-mounted, compressor-condenser components on 4-inch-thick, reinforced concrete base; 4 inches larger on each side than unit. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.

G. Install ground-mounted compressor-condenser components on polyethylene mounting base.

H. Install roof-mounted compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

3.03 PIPING CONNECTIONS

A. Gas piping installation requirements are specified in [**Section 231123 "Facility Natural-Gas Piping."**] [**Section 231126 "Facility Liquefied-Petroleum Gas Piping."**] Drawings indicate general arrangement of piping, fittings, and specialties. Connect gas piping with union or flange and appliance connector valve.

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

C. Water piping installation requirements are specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties. Connect water piping with union and ball valve.

D. Vent Connection, Noncondensing, Gas-Fired Furnaces: Connect Type B vents to furnace vent connection and extend outdoors. Type B vents and their installation requirements are specified in Section 235123 "Gas Vents."

E. Vent and Outside-Air Connection, Condensing, Gas-Fired Furnaces: Connect plastic piping vent material to furnace connections and extend outdoors. Terminate vent outdoors with a cap and in an arrangement that will protect against entry of birds, insects, and dirt.

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

2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   a. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
   b. CPVC Piping: Join according to ASTM D2846/D2846M, Appendix.
   c. PVC Pressure Piping: Join schedule number ASTM D1785 PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D2855.
4. Slope pipe vent back to furnace or to outside terminal.

F. Connect refrigerant tubing kits to refrigerant coil in furnace and to air-cooled compressor-condenser unit.
1. Flared Joints: Use ASME B16.26 fitting and flared ends, following procedures in CDA's "Copper Tube Handbook."
2. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
3. 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.

G. Comply with requirements in Section 232300 "Refrigerant Piping" for installation and joint construction of refrigerant piping.

3.04 DUCTWORK CONNECTIONS

A. Connect ducts to furnace with flexible connector. Comply with requirements in Section 233300 "Air Duct Accessories."

3.05 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.06 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.07 STARTUP SERVICE

A. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
1. Inspect for physical damage to unit casings.
2. Verify that access doors move freely and are weathertight.
3. Clean units and inspect for construction debris.

4. Verify that all bolts and screws are tight.
5. Adjust vibration isolation and flexible connections.
6. Verify that controls are connected and operational.

B. Adjust fan belts to proper alignment and tension.

C. Start unit according to manufacturer's written instructions and complete manufacturer's operational checklist.

D. Measure and record airflows.

E. Verify proper operation of capacity control device.

F. After startup and performance test, lubricate bearings[**and adjust belt tension**].

3.08 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set controls, burner, and other adjustments for optimum heating performance and efficiency. Adjust heat-distribution features, including shutters, dampers, and relays, to provide optimum heating performance and system efficiency.

3.09 CLEANING

A. After completing installation, clean furnaces internally according to manufacturer's written instructions.

B. Install new filters in each furnace within 14 days after Substantial Completion.

3.10 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Perform electrical test and visual and mechanical inspection.
2. Leak Test: After installation, charge systems with refrigerant and test for leaks. Repair leaks, replace lost refrigerant, and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
4. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain condensing units. Refer to Section 017900 "Demonstration and Training."

END OF SECTION

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SECTION 235533.16
GAS-FIRED UNIT HEATERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Gas-fired unit heaters.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of gas-fired unit heater.
   1. Include rated capacities, operating characteristics, and accessories.
B. Shop Drawings: Include plans, elevations, sections, and attachment details.
   1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Include diagrams for power signal and control wiring.

1.03 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gas-fired unit heaters to include in emergency, operation, and maintenance manuals.

1.04 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace heat exchanger of gas-fired unit heater that fails in materials or workmanship within specified warranty period.
   1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 GAS-FIRED UNIT HEATERS

A. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.
B. Gas Type: Design burner for natural gas having characteristics same as those of gas available at Project site.
C. Type of Venting: Indoor, separated combustion, power vented.
D. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.
   1. External Casings and Cabinets: Baked enamel or Powder coating over corrosion-resistant-treated surface.
   2. Discharge Louvers: Independently adjustable, horizontal blades.
   3. Discharge Nozzle: Discharge at [**25 to 65 degrees**] [**50 to 90 degrees**] from horizontal.
E. Accessories:
   1. Four-point suspension kit or field-fabricated brackets.
   2. Power Venter: Centrifugal aluminized-steel fan, with stainless steel shaft; 120-V ac motor.
   3. Concentric, Terminal Vent Assembly: Combined combustion-air inlet and power-vent outlet with wall or roof caps. Include adapter assembly for connection to inlet and outlet pipes, and flashing for wall or roof penetration.
F. Heat Exchanger: Stainless steel.
G. Propeller Unit Fan:
   1. Propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.
   2. Fan-Blade Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
H. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

1. Gas Control Valve: Single stage.
2. Ignition: Electronically controlled electric spark with flame sensor.
3. Control transformer.
4. High Limit: Thermal switch or fuse to stop burner.
5. Thermostat:
   a. Mounting: Wall.
   b. Single stage.
   c. Fan on-off-automatic switch.
   d. 24-V ac.
   e. 50 to 90 deg F operating range.

I. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install and connect gas-fired unit heaters and associated gas and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written instructions.

3.02 EQUIPMENT MOUNTING

A. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

B. Substrate-Mounted Units: Provide supports connected to substrate. Secure units to supports.
   1. Threaded Rods, Spring Hangers, and Building Attachments: Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment".

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to gas-fired unit heater, allow space for service and maintenance.

C. Gas Piping: Comply with Section 231123 "Facility Natural-Gas Piping." Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   2. Verify bearing lubrication.
   3. Verify proper motor rotation.
   4. Test Reports: Prepare a written report to record the following:
      a. Test procedures used.
      b. Test results that comply with requirements.
      c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

B. Gas-fired unit heater will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.05 ADJUSTING

A. Adjust initial temperature set points.

B. Adjust burner and other unit components for optimum heating performance and efficiency.

END OF SECTION

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SECTION 237416.11
PACKAGED, SMALL-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Packaged, small-capacity, rooftop air-conditioning units (RTUs) with the following components:
   1. Unit casings.
   2. Fans, drives, and motors.
   3. Rotary heat exchanger.
   4. Coils.
   5. Refrigerant circuit components.
   6. Air filtration.
   7. Dampers.
   8. Electrical power connections.
   9. Controls.
   10. Roof curbs.
   11. Accessories.

1.02 DEFINITIONS

A. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, small-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

1.03 ACTION SUBMITTALS

A. Product Data: For each RTU.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   2. Include rated capacities, dimensions, required clearances, characteristics, and furnished specialties and accessories.
   3. Include unit dimensions and weight.
   4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
   5. Include certified coil-performance ratings with system operating conditions indicated.
   6. Include filters with performance characteristics.
   7. Include dampers, including housings, linkages, and operators.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For RTUs to include in operation, and maintenance manuals.

1.05 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. Filters: One set(s) of filters for each unit.
   2. Fan Belts: One set(s) for each belt-driven fan.

1.06 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of packaged, small-capacity, rooftop air-conditioning unit that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Manufacturer’s standard but not less than five years from the date of substantial completion. Warranty shall include parts, labor, and refrigerant from the manufacturer for the entire warranty period.
   2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of RTUs and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE 15 Compliance: For refrigeration system safety.

E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. UL Compliance: Comply with UL 1995.

2.02 ACCEPTABLE MANUFACTURERS

A. Trane as scheduled on drawings.

B. Approved equals from York, Carrier, or Daikin may be permitted provided that the full specification is met including all scheduled performance.

2.03 UNIT CASINGS

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Double-Wall Construction:

1. Outside Casing Wall: Galvanized steel, minimum 18 gauge thick with manufacturer's standard finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
2. Inside Casing Wall: G90-coated galvanized steel, 0.034 inch thick.
3. Floor Plate: G90 galvanized steel, treadplate, minimum 18 gauge thick.
4. Casing Insulation:
   a. Materials: Injected polyurethane foam insulation.
   b. Insulation Thickness: 1 inch.
   c. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.

C. Airstream Surfaces: Surfaces in contact with airstream to comply with requirements in ASHRAE 62.1.

D. Static-Pressure Classifications:

1. For Unit Sections Upstream of Fans: Minus 2-inch wg.
2. For Unit Sections Downstream and Including Fans: 2-inch wg.

E. Panels and Doors:

1. Panels:
   a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
   b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement to allow panels to be opened against air-pressure differential.
   c. Gasket: Neoprene, applied around entire perimeters of panel frames.
   d. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
2. Access Doors:
   a. Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.

b. Gasket: Neoprene, applied around entire perimeters of panel frames.
c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Locations and Applications:
a. Fan Section: Doors.
b. Access Section: Doors.
c. Coil Section: Inspection and access panels.
d. Damper Section: Doors.
e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
f. Mixing Section: Doors.

F. Condensate Drain Pans:
1. Location: Each type of cooling coil.
2. Construction:
a. Single-wall, galvanized-steel or noncorrosive polymer sheet.
3. Drain Connection:
a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
b. Minimum Connection Size: NPS 1.
4. Slope: Minimum 0.125-in./ft. slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
5. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
6. Width: Entire width of water producing device.
7. Depth: A minimum of 2 inches deep.
8. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
9. Units with stacked coils must have an intermediate drain pan to collect condensate from top coil.

2.04 FANS, DRIVES, AND MOTORS

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Supply-Air Fans: Centrifugal, rated according to AMCA 210; galvanized or painted steel; mounted on solid-steel shaft.
1. Shafts: With field-adjustable alignment.
a. Turned, ground, and polished hot-rolled steel with keyway.
2. Shaft Bearings:
a. Heavy-duty, self-aligning, pillow-block type with an L-50 rated life of minimum 100,000 hours according to ABMA 9.
3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
4. Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.

5. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.
6. Shaft Lubrication Lines: Extended to a location outside the casing.
7. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet.
   a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives to comply with UL 181, Class 1.

C. Drives, Direct: Factory-mounted, direct drive.

D. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated ECM motors.

E. Relief-Air Fan: Airfoil, shaft mounted on permanently lubricated motor.

F. Motors:
1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "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. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.05 COILS

A. General Requirements for Coils:
1. Comply with AHRI 410.
2. Fabricate coils section to allow for removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils to not act as structural component of unit.

B. Supply-Air Refrigerant Coil:
1. Tubes: Copper.
2. Fins:
   a. Material: Aluminum.
3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: Galvanized steel.
6. Coatings: None.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.
   a. Working Pressure: Minimum 300 psig.

C. Outdoor-Air Refrigerant Coil:
1. Tubes: Copper.
2. Fins:
   a. Material: Aluminum.
3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: Galvanized steel.
6. Coatings: None.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

a. Working Pressure: Minimum 300 psig.

D. Hot-Gas Reheat Refrigerant Coil:
1. Tubes: Copper.
2. Fins:
a. Material: Aluminum.
3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: Galvanized steel.
6. Coatings: None.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.
a. Working Pressure: Minimum 300 psig.
8. Suction-discharge bypass valve.

E. Gas Furnace section:lectric-Resistance Heating Coils: Comply with UL 1995.
1. Factory assembled, piped, and wired in accordance with ANSI Z21.47 and NFPA 54.
2. Burners: Stainless Steel.
a. Fuel: natural gas.
b. Ignition: direct spark.
c. Gas control valve: Modulating.
d. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing solenoid valve, filter, pressure regulator, automatic and manual shutoff.
e. Venting: Power vented with fan interlocked with gas valve.
f. Gas manifold: Safety switches and controls complying with ANSI standards.

2.06 REFRIGERANT CIRCUIT COMPONENTS

A. Compressor: Hermetic, variable-speed scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief.

B. Refrigeration Specialties:
1. Refrigerant: R-454B.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.
9. Hot-gas reheat solenoid valve modulating with a replaceable magnetic coil.
10. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

2.07 AIR FILTRATION

A. Standard throwaway filter as recommended by manufacturer.

2.08 DAMPERS

A. Comply with requirements in Section 230923.12 "Control Dampers."

B. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in parallel-blade arrangement withsteel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate must not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg rated in accordance with AMCA 500D.

C. Barometric relief dampers.

D. Electronic Damper Operators:
   1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
   2. Electronic damper position indicator to have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
   3. Operator Motors:
      a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
      b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
      c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

2.09 ELECTRICAL POWER CONNECTIONS

A. RTU to have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.10 CONTROLS

A. Basic Unit Controls:
   1. Control-voltage transformer.
   2. Wall-mounted thermostat or sensor with the following features:
      a. Heat-cool-off switch.
      b. Fan on-auto switch.
      c. Fan-speed switch.
      d. Automatic changeover.
      e. Adjustable deadband.
      f. Exposed set point.
      g. Exposed indication.
      h. Degree F indication.
      i. Unoccupied-period-override push button.
      j. Data entry and access port to input temperature and humidity set points, occupied and unoccupied periods, and output room temperature and humidity, supply-air temperature, operating mode, and status.
   3. Wall-mounted humidistat or sensor with the following features:
      a. Exposed set point.
      b. Exposed indication.
   4. Annunciator Panel for Each Unit:
      a. Configuration: Unit-mounted.
      b. Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
      c. DDC controller or programmable timer and interface with HVAC instrumentation and control system.
      d. Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.

B. Controller:
   1. Type: Electronic.
   2. Controller to have volatile-memory backup.

3. Safety Control Operation:
   a. Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.
4. Scheduled Operation: Occupied and unoccupied periods on seven 365-day clock with a minimum of two programmable periods per day.
5. Unoccupied Period:
   a. Heating Setback: 10 deg F.
   b. Cooling Setback: System off.
   c. Override Operation: Two hours.
6. Supply Fan Operation:
   a. Occupied Periods: Run fan continuously.
   b. Unoccupied Periods: Cycle fan to maintain setback temperature.
7. Refrigerant Circuit Operation:
   a. Occupied Periods: Cycle or stage compressors to match compressor output to cooling load to maintain room temperature and humidity. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
   b. Unoccupied Periods: Cycle compressors and condenser fans for heating to maintain setback temperature.
   c. Switch reversing valve for heating or cooling mode on air-to-air heat pump.
8. Hot-Gas Reheat-Coil Operation:
   a. Occupied Periods: Humidistat opens hot-gas valve to provide hot-gas reheat, and cycles the compressor.
   b. Unoccupied Periods: Reheat not required.
9. Gas Furnace-Heating Operation:
   a. Occupied Periods: Stage heat to maintain room temperature.
   b. Unoccupied Periods: Cycle heat to maintain setback temperature.
10. Fixed Minimum Outdoor-Air Damper Operation:
   a. Occupied Periods: Open to 25 percent.
   b. Unoccupied Periods: Close the outdoor-air damper.
11. Economizer Outdoor-Air Damper Operation:
   a. Morning warm-up cycles.
   b. Occupied Periods: Open to 25 percent fixed minimum intake, and maximum 100 percent of the fan capacity. Controller is to permit air-side economizer operation when outdoor air is less than 60 deg F. Use outdoor-air enthalpy to adjust mixing dampers. Start relief-air fan with end switch on outdoor-air damper. During economizer cycle operation, lock out cooling.
   c. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
   d. Outdoor-Airflow Monitor: Accuracy maximum plus or minus 5 percent within 15 and 100 percent of total outdoor air.

2.11 ROOF CURBS

A. 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 C1071, Type I or II.
      b. Thickness: 2 inches.
   2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
      a. Liner Adhesive: Comply with ASTM C916, 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 to have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.

B. Curb Dimensions: Height of 14 inches and sloped to match roof slope.

2.12 ACCESSORIES

A. Safeties:
1. Smoke detector.
2. Condensate overflow switch.
3. Phase-loss and reversal protection.
4. Egas furnace airflow-proving switch.

B. Hail guards of galvanized steel, painted to match casing.
C. Outdoor-air intake weather hood.

2.13 MATERIALS

A. Steel:
1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:
1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.
D. Aluminum: ASTM B209.

2.14 SOURCE QUALITY CONTROL

A. AHRI Compliance:
1. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.
2. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
3. Comply with AHRI 270 for testing and rating sound performance for RTUs.
4. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.

B. AMCA Compliance:
1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Damper leakage tested according to AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
B. Examine roughing-in for RTUs to verify actual locations of piping 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.

3.02 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." Install RTUs on curbs and

coordinate roof penetrations and flashing with roof construction. Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.

B. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

C. Equipment Mounting:

1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.03 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to RTU, allow space for service and maintenance.

C. Connect piping to unit mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

3.04 DUCT CONNECTIONS

A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate 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 Section 233300 "Air Duct Accessories."
4. Install return-air duct continuously through roof structure.

3.05 ELECTRICAL CONNECTIONS

A. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate is to be laminated acrylic or melamine plastic signs as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate is to be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least 1/2 inch high.
3. Locate nameplate where easily visible.

3.06 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.07 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Inspect for visible damage to unit casing.
3. Inspect for visible damage to furnace combustion chamber.

4. Inspect for visible damage to compressor, coils, and fans.
5. Inspect internal insulation.
6. Verify that labels are clearly visible.
7. Verify that clearances have been provided for servicing.
8. Verify that controls are connected and operable.
9. Verify that filters are installed.
10. Clean condenser coil and inspect for construction debris.
11. Clean furnace flue and inspect for construction debris.
12. Connect and purge gas line.
13. Remove packing from vibration isolators.
14. Inspect operation of barometric relief dampers.
15. Verify lubrication on fan and motor bearings.
16. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
17. Adjust fan belts to proper alignment and tension.
18. Start unit according to manufacturer's written instructions.
    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.
19. Inspect and record performance of interlocks and protective devices; verify sequences.
20. Operate unit for an initial period as recommended or required by manufacturer.
21. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency:
    a. Measure gas pressure on manifold.
    b. Inspect operation of power vents.
    c. Measure combustion-air temperature at inlet to combustion chamber.
    d. Measure flue-gas temperature at furnace discharge.
    e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
22. Calibrate thermostats.
23. Adjust and inspect high-temperature limits.
24. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
25. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:
    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.
26. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
27. 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.

28. Simulate maximum cooling demand and inspect the following:
    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
29. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
    a. High-temperature limit on gas-fired heat exchanger.
    b. Low-temperature safety operation.
    c. Filter high-pressure differential alarm.
    d. Economizer to minimum outdoor-air changeover.
    e. Relief-air fan operation.
    f. Smoke and firestat alarms.
30. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.08 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

C. Occupancy Adjustments: When requested within 12 months from 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.

3.09 CLEANING

A. After completing system installation and testing, adjusting, and balancing RTUs and air-distribution systems, clean RTUs internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. 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.

C. RTU will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION

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SECTION 238123.11
SMALL CAPACITY (LESS THAN 7 TONS), COMPUTER-ROOM AIR-CONDITIONERS, FLOOR-MOUNTED UNITS

PART 1 - PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Small capacity (less than 7 tons), computer-room air-conditioners, floor-mounted units.
   2. Manufactured units.

1.02 DEFINITIONS

A. SCR: Silicon controlled rectifier.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include material descriptions, dimensions of individual components and profiles, and finishes for computer-room air-conditioning units and outdoor air-cooled condensers.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For computer-room air conditioners.
   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For computer-room air conditioners to include in operation, and maintenance manuals.

1.05 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
   2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
   3. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

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. ASHRAE Compliance:
   1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

2.02 SMALL CAPACITY (LESS THAN 7 TONS), COMPUTER-ROOM AIR-CONDITIONERS, FLOOR-MOUNTED UNITS

A. Acceptable Manufacturers
   1. Vertiv Liebert as scheduled on drawings.
   2. Approved equals from other manufacturers may be considered only if offered and pre-approved in writing prior to the closing date for questions during the bid period.

B. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in downflow configuration.

C. Cabinet and Frame: Welded tubular-steel frame with removable, insulated steel panels with powder coated, RAL7021 black gray matte color paint for corrosion protection.
   1. Floor Stand: Welded tubular steel, 20” high, with adjustable legs and vibration isolation pads.

D. Supply Fan:
   1. Electronically Commutated plug type, integral direct-driven, aluminum impeller, with backward curved blades regulated automatically through all modes of operation

E. Refrigeration System:
   1. Compressor: Digital Scroll, variable capacity, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
   2. Refrigeration Circuit:
      a. Liquid line filter drier.ow-pressure switch.
      b. Sight glass with moisture indicator.
      c. Thermal-expansion valve.
      d. Pressure safety switch.
      e. Liquid line solenoid valve.
      f. Service shutoff valves.
      g. Charging valves.
   3. Refrigerant: R-410A.
   4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.
   5. Refrigerant line sets.
   6. Refrigerant line-sweat-adapter kit to permit field brazing of refrigerant lines.
      a. Mount stainless-steel drain pan under coil assembly.
   7. Remote Air-Cooled Refrigerant Condenser:
      a. Integral, copper-tube aluminum-fin coil.
      b. Condenser with surge protection device (SPD) and locking disconnect in the enclosed electrical panel section.
   8. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

F. Electric-Resistance Reheat Coil:
   1. Finned-tube electric elements with contactor and high-temperature-limit switches.
   2. SCR to proportionally control the reheat elements providing precise temperature control.

G. Filter: 2-inch thick, disposable, pleated, MERV 8, glass-fiber media.

H. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and located in bypass airstream; with flush-cycle timer and solenoid drain valve.

I. Disconnect Switch:
   1. Locking, fused disconnect with handle accessible with the door closed.

J. Control System:
   1. Microprocessor unit-mounted panel.
   2. Fan contactor.
   3. Compressor contactor.
   4. Compressor start capacitor.
   5. Control transformer with circuit breaker.
   6. Solid-state temperature-and humidity-control modules.

7. Humidity contactor.
8. Time-delay relay.
9. Heating contactor.
10. Smoke sensor.
11. High-temperature thermostat.
12. Solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, remote temperature sensors, remote humidity sensors and adjustable temperature set point.
13. Remote panel to monitor and change temperature and humidity set points and sensitivities of the unit and unit alarms.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.

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

3.02 INSTALLATION

A. Layout and install computer-room air conditioners coordinated with other construction including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Install computer-room air conditioners coordinated with computer-room access flooring Installer.

C. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances.

D. Air-Cooled Refrigerant Condenser Mounting: Install using elastomeric pads on structural frame. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room air conditioners 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.

C. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. After startup service and performance test, change filters and flush humidifier.

3.04 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.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION

SECTION 238123.12
LARGE CAPACITY (7 TONS AND LARGER), COMPUTER-ROOM AIR-CONDITIONERS, FLOOR-MOUNTED UNITS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Large capacity (7 tons and larger), computer-room air-conditioners, floor-mounted units.

1.02 DEFINITIONS

A. SCR: Silicon controlled rectifier.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include material descriptions, dimensions of individual components and profiles, and finishes for computer-room air-conditioning units and outdoor air-cooled condensers.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For computer-room air conditioners.
   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For computer-room air conditioners to include in operation, and maintenance manuals.

1.05 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
   2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
   3. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

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. ASHRAE Compliance:
   1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

2.02 SMALL CAPACITY (7 TONS AND LARGER), COMPUTER-ROOM AIR-CONDITIONERS, FLOOR-MOUNTED UNITS

A. Acceptable Manufacturers
   1. Vertiv Liebert as scheduled on drawings.
   2. Approved equals from other manufacturers may be considered only if offered and pre-approved in writing prior to the closing date for questions during the bid period.

B. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in downflow configuration.

C. Cabinet and Frame: Welded tubular-steel frame with removable, insulated steel panels with powder coated, RAL7021 black gray matte color paint for corrosion protection.
   1. Floor Stand: Welded tubular steel, 20” high, with adjustable legs and vibration isolation pads.

D. Supply Fan:
   1. Electronically Commutated plug type, integral direct-driven, aluminum impeller, with backward curved blades regulated automatically through all modes of operation

E. Refrigeration System:
   1. Compressor: Digital Scroll, variable capacity, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
   2. Refrigeration Circuit:
      a. Two independent refrigeration circuits.
      b. Liquid line filter drier.
      c. Low-pressure switch.
      d. Sight glass with moisture indicator.
      e. Thermal-expansion valve.
      f. Pressure safety switch.
      g. Liquid line solenoid valve.
      h. Service shutoff valves.
      i. Charging valves.
   3. Refrigerant: R-407C.
   4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.
   5. Refrigerant line sets.
   6. Refrigerant line-sweat-adapter kit to permit field brazing of refrigerant lines.
      a. Mount stainless-steel drain pan under coil assembly.
   7. Remote Air-Cooled Refrigerant Condenser:
      a. Integral, copper-tube aluminum-fin coil.
      b. Condenser with surge protection device (SPD) and locking disconnect in the enclosed electrical panel section.
   8. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

F. Electric-Resistance Reheat Coil:
   1. Finned-tube electric elements with contactor and high-temperature-limit switches.
   2. SCR to proportionally control the reheat elements providing precise temperature control.

G. Filter: 4-inch thick, disposable, pleated, MERV 8, glass-fiber media.

H. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and located in bypass airstream; with flush-cycle timer and solenoid drain valve.

I. Disconnect Switch:
   1. Locking disconnect with handle accessible with the door closed.
   2. Electrical panel shall provide at least 65,000A Short Circuit Current Rating (60Hz).

J. Control System:
   1. Microprocessor unit-mounted panel.
   2. Fan contactor.
   3. Compressor contactor.
   4. Compressor start capacitor.
   5. Control transformer with circuit breaker.

6. Solid-state temperature-and humidity-control modules.
7. Humidity contactor.
8. Time-delay relay.
9. Heating contactor.
10. Smoke sensor.
11. High-temperature thermostat.
12. Solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, remote temperature sensors, remote humidity sensors and adjustable temperature set point.
13. Remote panel to monitor and change temperature and humidity set points and sensitivities of the unit and unit alarms.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.

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

3.02 INSTALLATION

A. Layout and install computer-room air conditioners coordinated with other construction including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Install computer-room air conditioners coordinated with computer-room access flooring Installer.

C. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances.

D. Air-Cooled Refrigerant Condenser Mounting: Install using elastomeric pads on structural frame. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room air conditioners 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.

C. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. After startup service and performance test, change filters and flush humidifier.

3.04 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.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION

SECTION 238126
SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.05 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. Filters: One replacement for each indoor unit.

1.06 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. ASHRAE Compliance:
   1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
   2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.07 COORDINATION

A. Coordinate sizes and locations of pads, roof curbs, equipment supports, and building penetrations with actual equipment provided.

1.08 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:
      a. For Compressor: Five years from date of Substantial Completion.
      b. For Parts: Five years from date of Substantial Completion.
      c. For Labor: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: basis-of-design products are Mitsubishi Electric & Electronics USA, Inc as scheduled on drawings.

B. Subject to compliance with requirements, approved equals may be provided from one of the following.
   1. LG.

2. Samsung.
3. Fujitsu.

2.02 INDOOR UNITS (5 TONS OR LESS)

A. Wall- and Ceiling-Mounted, Evaporator-Fan Components:
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
3. Fan: Direct drive, centrifugal.
4. Fan Motors:
   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
   c. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
6. Condensate Drain Pans:
   a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
7. Air Filtration Section:
   a. General Requirements for Air Filtration Section:
      1) Comply with NFPA 90A.
      2) Minimum MERV according to ASHRAE 52.2.
      3) 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.

2.03 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:
1. Casing: Steel, finished with baked enamel and 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.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
   a. Compressor Type: Scroll.
   b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
   c. Refrigerant: R-454B.
   d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
   e. Multi-zone: With separate refrigerant circuits for multiple indoor fan coil units.
3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 0 deg F.

7. Mounting Base: Polyethylene.

2.04 ACCESSORIES

A. Outdoor ventilation connection port on indoor unit cabinet for connection of duct from outside air source.

B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

C. Automatic-reset timer to prevent rapid cycling of compressor.

D. 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.

E. Drain Hose: For condensate.

PART 3 - EXECUTION

3.01 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 outdoor unit on pad at grade or roof-mounted on equipment supports as indicated on Drawings. Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:

1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.02 CONNECTIONS

A. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

B. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect outside air ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

3.03 FIELD QUALITY CONTROL

A. 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.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.04 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.05 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION

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SECTION 260010
SUPPLEMENTAL REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Supplemental requirements generally applicable to the Work specified in Division 26. This Section is also referenced by related Work specified in other Divisions.

1.02 REFERENCES

A. Abbreviations and Acronyms for Electrical Terms and Units of Measure:

1. 8P8C: An 8-position 8-contact modular jack.
2. A: Ampere, unit of electrical current.
3. AC or ac: Alternating current.
4. AIC: Ampere interrupting capacity.
5. ATS: Automatic transfer switch.
6. AWG: American wire gauge; see ASTM B258.
7. BAS: Building automation system.
8. BIL: Basic impulse insulation level.
9. BIM: Building information modeling.
10. CAD: Computer-aided design or drafting.
11. CATV: Community antenna television.
12. CB: Circuit breaker.
13. cd: Candela, the SI fundamental unit of luminous intensity.
14. CO/ALR: Copper-aluminum, revised.
15. CU or Cu: Copper.
16. dB: Decibel, a unitless logarithmic ratio of two electrical, acoustical, or optical power values.
17. dB(A-weighted) or dB(A): Decibel acoustical sound pressure level with A-weighting applied in accordance with IEC 61672-1.
18. dB(adjusted) or dBa: Decibel weighted absolute noise power with respect to 3.16 pW (minus 85 dBm).
19. dBm: Decibel absolute power with respect to 1 mW.
20. DC or dc: Direct current.
21. DDC: Direct digital control (HVAC).
22. EGC: Equipment grounding conductor.
23. ELV: Extra-low voltage.
24. EMF: Electromotive force.
25. EMI: Electromagnetic interference.
26. EPM: Electrical preventive maintenance.
27. EPS: Emergency power supply.
28. EPSS: Emergency power supply system.
29. ESS: Energy storage system.
30. fc: Footcandle, an internationally recognized unit of illuminance equal to one lumen per square foot or 10.76 lx. The simplified conversion 1 fc = 10 lx in the Specifications is common practice and considered adequate precision for building construction activities. When there are conflicts, lux is the primary unit; footcandle is specified for convenience.
31. FLC: Full-load current.
32. ft: Foot.

33. ft-cd: Foot-candle, the antiquated U.S. Standard unit of illuminance, equal to one international candle measured at a distance of one foot, that was superseded in 1948 by the unit "footcandle" after the SI unit candela (cd) replaced the international candle; see "fc,"
34. GEC: Grounding electrode conductor.
35. GFCI: Ground-fault circuit interrupter.
36. GFPE: Ground-fault protection of equipment.
37. GND: Ground.
38. HACR: Heating, air conditioning, and refrigeration.
39. HDPE: High-density polyethylene.
40. HID: High-intensity discharge.
41. HP or hp: Horsepower.
42. HVAC: Heating, ventilating, and air conditioning.
43. Hz: Hertz.
44. IBT: Intersystem bonding termination.
45. inch: Inch. To avoid confusion, the abbreviation "in." is not used.
46. IP: Ingress protection rating (enclosures); Internet protocol (communications).
47. IR: Infrared.
48. IS: Intrinsically safe.
49. IT&R: Inspecting, testing, and repair.
50. ITE: Information technology equipment.
51. kAIC: Kiloampere interrupting capacity.
52. kcmil or MCM: One thousand circular mils.
53. kV: Kilovolt.
54. kVA: Kilovolt-ampere.
55. kVAr or kVAR: Kilovolt-ampere reactive.
56. kW: Kilowatt.
57. kWh: Kilowatt-hour.
58. LAN: Local area network.
59. lb: Pound (weight).
60. lbf: Pound (force).
61. LCD: Liquid-crystal display.
62. LCDI: Leakage-current detector-interrupter.
63. LED: Light-emitting diode.
64. Li-ion: Lithium-ion.
65. lm: Lumen, the SI derived unit of luminous flux.
66. LNG: Liquefied natural gas.
67. LP-Gas: Liquefied petroleum gas.
68. LRC: Locked-rotor current.
69. LV: Low voltage.
70. lx: Lux, the SI derived unit of illuminance equal to one lumen per square meter.
71. m: Meter.
72. MDC: Modular data center.
73. MG set: Motor-generator set.
74. MIDI: Musical instrument digital interface.
75. MLO: Main lugs only.
76. MV: Medium voltage.
77. MVA: Megavolt-ampere.
78. mW: Milliwatt.

79. MW: Megawatt.
80. MWh: Megawatt-hour.
81. NC: Normally closed.
82. Ni-Cd: Nickel-cadmium.
83. Ni-MH: Nickel-metal hydride.
84. NIU: Network interface unit.
85. NO: Normally open.
86. NPT: National (American) standard pipe taper.
87. OCPD: Overcurrent protective device.
88. ONT: Optical network terminal.
89. PC: Personal computer.
90. PCS: Power conversion system.
91. PCU: Power-conditioning unit.
92. PF or pf: Power factor.
93. PHEV: Plug-in hybrid electric vehicle.
94. PLC: Programmable logic controller.
95. PLFA: Power-limited fire alarm.
96. PoE: Power over Ethernet.
97. PV: Photovoltaic.
98. PVC: Polyvinyl chloride.
99. pW: Picowatt.
100. RFI: (electrical) Radio-frequency interference; (contract) Request for interpretation.
101. RMS or rms: Root-mean-square.
102. RPM or rpm: Revolutions per minute.
103. SCADA: Supervisory control and data acquisition.
104. SCR: Silicon-controlled rectifier.
105. SPD: Surge protective device.
106. sq.: Square.
107. SWD: Switching duty.
108. TCP/IP: Transmission control protocol/Internet protocol.
109. TEFC: Totally enclosed fan-cooled.
110. TR: Tamper resistant.
111. TVSS: Transient voltage surge suppressor.
112. UL: (standards) Underwriters Laboratories, Inc.; (product categories) UL, LLC.
113. UL CCN: UL Category Control Number.
114. UPS: Uninterruptible power supply.
115. USB: Universal serial bus.
116. UV: Ultraviolet.
117. V: Volt, unit of electromotive force.
118. V(ac): Volt, alternating current.
119. V(dc): Volt, direct current.
120. VA: Volt-ampere, unit of complex electrical power.
121. VAR: Volt-ampere reactive, unit of reactive electrical power.
122. VFC: Variable-frequency controller.
123. VOM: Volt-ohm-multimeter.
124. VPN: Virtual private network.
125. VRLA: Valve regulated lead acid; also called "sealed lead acid (SLA)" or "valve regulated sealed lead acid."
126. W: Watt, unit of real electrical power.

127. Wh: Watt-hour, unit of electrical energy usage.
128. WPT: Wireless power transfer.
129. WPTE: Wireless power transfer equipment.
130. WR: Weather resistant.

B. Abbreviations and Acronyms for Electrical Raceway Types:
1. EMT: Electrical metallic tubing.
2. EMT-S: Steel electrical metallic tubing.
3. ERMC: Electrical rigid metal conduit.
4. ERMC-S: Steel electrical rigid metal conduit.
5. ERMC-S-G: Galvanized-steel electrical rigid metal conduit.
6. ERMC-SS: Stainless steel electrical rigid metal conduit.
7. FMC: Flexible metal conduit.
8. FMC-S: Steel flexible metal conduit.
9. FMT: Steel flexible metallic tubing.
10. HDPE: HDPE underground conduit (thick wall).
11. HDPE-40: Schedule 40 HDPE underground conduit.
12. IMC: Steel electrical intermediate metal conduit.
13. LFMC: Liquidtight flexible metal conduit.
14. LFMC-S: Steel liquidtight flexible metal conduit.
15. LFMC-SS: Stainless steel liquidtight flexible metal conduit.
16. PVC: Rigid PVC conduit.
17. PVC-40: Schedule 40 rigid PVC conduit.
18. PVC-80: Schedule 80 rigid PVC Conduit.
19. PVC-A: Type A rigid PVC concrete-encased conduit.
20. PVC-EB: Type EB rigid PVC concrete-encased underground conduit.
21. RGS: See ERMC-S-G.
22. RMC: See ERMC.
23. RSC: See ERMC.

C. Abbreviations and Acronyms for Electrical Single-Conductor and Multiple-Conductor Cable Types:
1. AC: Armored cable.
2. CATV: Coaxial general-purpose cable.
3. CATVP: Coaxial plenum cable.
4. CATVR: Coaxial riser cable.
5. CI: Circuit integrity cable.
6. CL2: Class 2 cable.
7. CL2P: Class 2 plenum cable.
8. CL2R: Class 2 riser cable.
9. CL2X: Class 2 cable, limited use.
10. CL3: Class 3 cable.
11. CL3P: Class 3 plenum cable.
12. CL3R: Class 3 riser cable.
13. CL3X: Class 3 cable, limited use.
14. CM: Communications general-purpose cable.
15. CMG: Communications general-purpose cable.
16. CMP: Communications plenum cable.
17. CMR: Communications riser cable.
18. CMUC: Under-carpet communications wire and cable.
19. CMX: Communications cable, limited use.

20. DG: Distributed generation cable.
21. FC: Flat cable.
22. FCC: Flat conductor cable.
23. FPL: Power-limited fire-alarm cable.
24. FPLP: Power-limited fire-alarm plenum cable.
25. FPLR: Power-limited fire-alarm riser cable.
26. IGS: Integrated gas spacer cable.
27. ITC: Instrumentation tray cable.
28. ITC-ER: Instrumentation tray cable, exposed run.
29. MC: Metal-clad cable.
30. MC-HL: Metal-clad cable, hazardous location.
31. MI: Mineral-insulated, metal-sheathed cable.
32. MTW: (machine tool wiring) Moisture-, heat-, and oil-resistant thermoplastic cable.
33. MV: Medium-voltage cable.
34. NPLF: Non-power-limited fire-alarm circuit cable.
35. NPLFP: Non-power-limited fire-alarm circuit cable for environmental air spaces.
36. NPLFR: Non-power-limited fire-alarm circuit riser cable.
37. NUCC: Nonmetallic underground conduit with conductors.
38. OFC: Conductive optical fiber general-purpose cable.
39. OFCG: Conductive optical fiber general-purpose cable.
40. OFCP: Conductive optical fiber plenum cable.
41. OFCR: Conductive optical fiber riser cable.
42. OFN: Nonconductive optical fiber general-purpose cable.
43. OFNG: Nonconductive optical fiber general-purpose cable.
44. OFNP: Nonconductive optical fiber plenum cable.
45. OFNR: Nonconductive optical fiber riser cable.
46. PLTC: Power-limited tray cable.
47. PLTC-ER: Power-limited tray cable, exposed run.
48. RHH: (high heat) Thermoset rubber, heat-resistant cable.
49. RHW: Thermoset rubber, moisture-resistant cable.
50. SA: Silicone rubber cable.
51. SIS: Thermoset cable for switchboard and switchgear wiring.
52. TBS: Thermoplastic cable with outer braid.
53. TC: Tray cable.
54. TC-ER: Tray cable, exposed run.
55. TC-ER-HL: Tray cable, exposed run, hazardous location.
56. THW: Thermoplastic, heat- and moisture-resistant cable.
57. THHN: Thermoplastic, heat-resistant cable with nylon jacket outer sheath.
58. THHW: Thermoplastic, heat- and moisture-resistant cable.
59. THWN: Thermoplastic, moisture- and heat-resistant cable with nylon jacket outer sheath.
60. TW: Thermoplastic, moisture-resistant cable.
61. XHH: Cross-linked polyethylene, heat-resistant cable.
62. XHHW: Cross-linked polyethylene, heat- and moisture-resistant cable.

D. Definitions:
   1. 8-Position 8-Contact (8P8C) Modular Jack: An unkeyed jack with up to eight contacts commonly used to terminate twisted-pair and multiconductor Ethernet cable. Also called a "TIA-1096 miniature 8-position series jack" (8PSJ), or an "IEC 8877 8-pole jack."

a. Be careful when suppliers use "RJ45" generically. Obsolete RJ45 jacks used for analog telephone cables have rejection keys. 8P8C jacks used for digital telephone cables and Ethernet cables do not have rejection keys.

2. Basic Impulse Insulation Level (BIL): Reference insulation level expressed in impulse crest voltage with a standard wave not longer than 1.5 times 50 microseconds and 1.5 times 40 microseconds.
3. Cable: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "cable" is (1) a conductor with insulation, or a stranded conductor with or without insulation (single-conductor cable); or (2) a combination of conductors insulated from one another (multiple-conductor cable).
4. Communications Jack: A fixed connecting device designed for insertion of a communications cable plug.
5. Communications Outlet: One or more communications jacks, or cables and plugs, mounted in a box or ring, with a suitable protective cover.
6. Conductor: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "conductor" is (1) a wire or combination of wires not insulated from one another, suitable for carrying an electric current; (2) (National Electrical Safety Code) a material, usually in the form of wire, cable, or bar, suitable for carrying an electric current; or (3) (general) a substance or body that allows a current of electricity to pass continuously along it.
7. Designated Seismic System: A system component that requires design in accordance with Ch. 13 of ASCE/SEI 7 and for which the Component Importance Factor is greater than 1.0.
8. Direct Buried: Installed underground without encasement in concrete or other protective material.
9. Enclosure: The case or housing of an apparatus, or the fence or wall(s) surrounding an installation, to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage. Types of enclosures and enclosure covers include the following:
   a. Cabinet: An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.
   b. Concrete Box: A box intended for use in poured concrete.
   c. Conduit Body: A means for providing access to the interior of a conduit or tubing system through one or more removable covers at a junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
   d. Conduit Box: A box having threaded openings or knockouts for conduit, EMT, or fittings.
   e. Cutout Box: An enclosure designed for surface mounting that has swinging doors or covers secured directly to and telescoping with the walls of the enclosure.
   f. Device Box: A box with provisions for mounting a wiring device directly to the box.
   g. Extension Ring: A ring intended to extend the sides of an outlet box or device box to increase the box depth, volume, or both.
   h. Floor Box: A box mounted in the floor intended for use with a floor box cover and other components to complete the floor box enclosure.

i. Floor-Mounted Enclosure: A floor box and floor box cover assembly with means to mount in the floor that is sealed against the entrance of scrub water at the floor level.
j. Floor Nozzle: An enclosure used on a wiring system, intended primarily as a housing for a receptacle, provided with a means, such as a collar, for surface-mounting on a floor, which may or may not include a stem to support it above the floor level, and is sealed against the entrance of scrub water at the floor level.
k. Junction Box: A box with a blank cover that joins different runs of raceway or cable and provides space for connection and branching of the enclosed conductors.
l. Outlet Box: A box that provides access to a wiring system having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for the entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting an outlet box cover, but without provisions for mounting a wiring device directly to the box.
m. Pedestal Floor Box Cover: A floor box cover that, when installed as intended, provides a means for typically vertical or near-vertical mounting of receptacle outlets above the floor's finished surface.
n. Pull Box: A box with a blank cover that joins different runs of raceway and provides access for pulling or replacing the enclosed cables or conductors.
o. Raised-Floor Box: A floor box intended for use in raised floors.
p. Recessed Access Floor Box: A floor box with provisions for mounting wiring devices below the floor surface.
q. Recessed Access Floor Box Cover: A floor box cover with provisions for passage of cords to recessed wiring devices mounted within a recessed floor box.
r. Ring: A sleeve, which is not necessarily round, used for positioning a recessed wiring device flush with the plaster, concrete, drywall, or other wall surface.
s. Ring Cover: A box cover, with raised center portion to accommodate a specific wall or ceiling thickness, for mounting wiring devices or luminaires flush with the surface.
t. Termination Box: An enclosure designed for installation of termination base assemblies consisting of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors, or both.

10. Emergency Systems: Those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction that are designed to ensure continuity of lighting, electrical power, or both, to designated areas and equipment in the event of failure of the normal supply for safety to human life.
11. Fault Limited: Providing or being served by a source of electrical power that is limited to not more than 100 W when tested in accordance with UL 62368-1.
    a. The term "fault limited" is intended to encompass most Class 1, 2, and 3 power-limited sources complying with Article 725 of NFPA 70; Class ES1 and ES2 electrical energy sources that are Class PS1 electrical power sources (e.g., USB); and Class ES3 electrical energy sources that are Class PS1 and PS2 electrical power sources (e.g., PoE). See UL 62368-1 for discussion of classes of electrical energy sources and classes of electrical power sources.
12. Jacket: A continuous nonmetallic outer covering for conductors or cables.
13. Luminaire: A complete lighting unit consisting of a light source such as a lamp, together with the parts designed to position the light source and connect it to the

power supply. It may also include parts to protect the light source or the ballast or to distribute the light.

14. Mode: The terms "Active Mode," "Off Mode," and "Standby Mode" are used as defined in the Energy Independence and Security Act (EISA) of 2007.
15. Multi-Outlet Assembly: A type of surface, flush, or freestanding raceway designed to hold conductors, receptacles, and switches, assembled in the field or at the factory.
16. Plenum: A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.
17. Receptacle: A fixed connecting device arranged for insertion of a power cord plug. Also called a power jack.
18. Receptacle Outlet: One or more receptacles mounted in a box with a suitable protective cover.
19. Sheath: A continuous metallic covering for conductors or cables.
20. UL Category Control Number (CCN): An alphabetic or alphanumeric code used to identify product categories covered by UL's Listing, Classification, and Recognition Services.
21. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:
    a. Control Voltage: Having electromotive force between any two conductors, or between a single conductor and ground, that is supplied from a battery or other Class 2 or Class 3 power-limited source.
    b. Line Voltage: (1) (controls) Designed to operate using the supplied low-voltage power without transformation. (2) (transmission lines, transformers, SPDs) The line-to-line voltage of the supplying power system.
    c. Extra-Low Voltage (ELV): Not having electromotive force between any two conductors, or between a single conductor and ground, exceeding 30 V(ac rms), 42 V(ac peak), or 60 V(dc).
    d. Low Voltage (LV): Having electromotive force between any two conductors, or between a single conductor and ground, that is rated above 30 V but not exceeding 1000 V.
    e. Medium Voltage (MV): Having electromotive force between any two conductors, or between a single conductor and ground, that is rated about 1 kV but not exceeding 69 kV.
    f. High Voltage: (1) (circuits) Having electromotive force between any two conductors, or between a single conductor and ground, that is rated above 69 kV but not exceeding 230 kV. (2) (safety) Having sufficient electromotive force to inflict bodily harm or injury.
22. Wire: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "wire" is a slender rod or filament of drawn metal. A group of small wires used as a single wire is properly called a "stranded wire." A wire or stranded wire covered with insulation is properly called an "insulated wire" or a "single-conductor cable." Nevertheless, when the context indicates that the wire is insulated, the term "wire" will be understood to include the insulation.

1.03 COORDINATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions:
    1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without Construction Manager's written permission.
3. Coordinate interruption with systems impacted by outage including, but not limited to, the following:
   a. Exercising generators.
   b. Emergency lighting.
   c. Fire-alarm systems.

B. Arrange to provide temporary electrical service or power in accordance with requirements specified in Division 01.

1.04 PREINSTALLATION MEETINGS

A. Electrical Preconstruction Conference: Schedule conference with Architect and Owner, not later than 10 days after notice to proceed. Agenda topics include, but are not limited to, the following:
1. Electrical installation schedule.
2. Status of power system studies.
3. Value analysis proposals and requests for substitution of electrical equipment.
4. Utility work coordination and class of service requests.
5. Commissioning activities.

1.05 SEQUENCING

A. Conduct and submit results of power system studies before submitting Product Data and Shop Drawings for electrical equipment.

1.06 ACTION SUBMITTALS

A. Coordination Drawings for Structural Supports: Show coordination of structural supports for equipment and devices.

B. Coordination Drawings for Large Equipment Indoor Installations:
1. Location plan, drawn to scale, showing heavy equipment or truck access paths to loading dock or other freight access into building. Indicate available width and height of doors or openings.
2. Floor plan for entry floor and floor where equipment is located, drawn to scale, showing heavy equipment access paths for maintenance and replacement, with the following items shown and coordinated with each other, based on input from installers of the items involved:
   a. Dimensioned concrete bases, outlines of equipment, conduit entries, and grounding equipment locations.
   b. If freight elevator must be used, indicate width and height of door and depth of car. Indicate if large equipment must be tipped to use elevator.
   c. Dimensioned working clearances and dedicated areas below and around electrical equipment where obstructions and tripping hazards are prohibited.
3. Reflected ceiling plans for entry floor and floor where equipment is located, drawn to scale, on which the following items shown and coordinated with each other, based on input from installers of the items involved:
   a. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways.
   b. Location of lighting fixtures, sprinkler piping and sprinklers, ducts and diffusers, and other obstructions, indicating available overhead clearance.
   c. Dimensioned working clearances and dedicated areas above and around electrical equipment where foreign systems and equipment are prohibited.

1.07 INFORMATIONAL SUBMITTALS

A. Electrical Installation Schedule: At preconstruction meeting, and periodically thereafter as dates change, provide schedule for electrical installation Work to Owner and Architect including, but not limited to, milestone dates for the following activities:
   1. Submission of power system studies.
   2. Submission of specified coordination drawings.
   3. Submission of action submittals specified in Division 26.
   4. Orders placed for major electrical equipment.
   5. Arrival of major electrical equipment on-site.
   6. Preinstallation meetings specified in Division 26.
   7. Utility service outages.
   8. Utility service inspection and activation.
   9. Closing of walls and ceilings containing electrical Work.
   10. System startup, testing, and commissioning activities for major electrical equipment.
   11. System startup, testing, and commissioning activities for emergency lighting.
   12. System startup, testing, and commissioning activities for automation systems (SCADA, BMS, lighting, HVAC, fire alarm, etc.).
   13. Pouring of concrete housekeeping pads for electrical equipment and testing of concrete samples.
   14. Requests for special inspections.
   15. Requests for inspections by authorities having jurisdiction.

1.08 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:
   1. Include the following information:
      a. Manufacturer's operating specifications.
      b. User's guides for software and hardware.
      c. Schedule of maintenance material items recommended to be stored at Project site.
      d. Detailed instructions covering operation under both normal and abnormal conditions.
      e. Time-current curves for overcurrent protective devices and manufacturer's written instructions for testing and adjusting their settings.
      f. List of load-current and overload-relay heaters with related motor nameplate data.
      g. List of lamp types and photoelectric relays used on Project, with ANSI and manufacturers' codes.
      h. Manufacturer's instructions for setting field-adjustable components.
      i. Manufacturer's instructions for testing, adjusting, and reprogramming microprocessor controls.
      j. EPSS: Manufacturer's system checklists, maintenance schedule, and maintenance log sheets in accordance with NFPA 110.
      k. Exterior pole inspection and repair procedures.

B. Software and Firmware Operational Documentation: Provide software and firmware operational documentation, including the following:
   1. Software operating and upgrade manuals.
   2. Names, versions, and website addresses for locations of installed software.
   3. Device address list.
   4. Printout of software application and graphic screens.
   5. Testing and adjusting of panic and emergency power features.
   6. For lighting controls, include the following:
      a. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.

b. Operation of adjustable zone controls.

1.09 QUALIFICATIONS

A. Generator Set Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by generator set manufacturer prior to starting installation.

B. Lightning Protection System Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired UL-Listed Installer, UL Category Control Number OWAY, credentials or unexpired LPI Master Installer credentials prior to starting installation.

C. Power Quality Specialist: Recognized experts possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction, and able to present unexpired NICET Level 4 credentials with documented experience in power quality testing for installations similar in complexity to this Project.

D. Low-Voltage Electrical Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.

1. On-site electrical testing supervisors must have documented certification and experience with testing electrical equipment in accordance with NETA testing standards.

E. Power-Limited Electrical Testing Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.

1. On-site power-limited testing supervisor must have BICSI Registered Communications Distribution Designer certification and documented training and experience with testing power-limited equipment in accordance with NETA testing standards.

1.10 FIELD CONDITIONS

A. Service Conditions for Electrical Power Equipment: Specified electrical power equipment must be suitable for operation under service conditions specified as usual service conditions in applicable NEMA PB series, IEEE C37 series, and IEEE C57 series standards.

PART 2 - PRODUCTS

2.01 SUBSTITUTION LIMITATIONS FOR ELECTRICAL EQUIPMENT

A. Substitution requests for electrical equipment will be entertained under the following conditions:

1. Substitution requests may be submitted for consideration concurrently with submission of power system study reports when those reports indicate that substitution is necessary for safety of maintenance personnel and facility occupants.
2. Contractor is responsible for sequencing and scheduling power system studies and electrical equipment procurement. After the Electrical Preconstruction Conference, insufficient lead time for electrical equipment delivery will not be considered a valid reason for substitution.

PART 3 - EXECUTION

3.01 INSTALLATION OF ELECTRICAL WORK

A. Unless more stringent requirements are specified in the Contract Documents or manufacturers' written instructions, comply with NFPA 70 and NECA NEIS 1 for installation of Work specified in Division 26. Consult Architect for resolution of conflicting requirements.

3.02 FIELD QUALITY CONTROL

A. Administrant for Low-Voltage Electrical Tests and Inspections:

1. Engage qualified low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.

B. Administrant for Power-Limited Electrical Tests and Inspections:
1. Engage qualified power-limited electrical testing and inspecting agency to administer and perform tests and inspections.

C. Administrant for Field Tests and Inspections of Lighting Installations:
1. Engage qualified lighting testing and inspecting agency to administer and perform tests and inspections.

3.03 CLOSEOUT ACTIVITIES

A. Demonstration: Demonstrate to Owner's maintenance and clerical personnel and building occupants how to operate the systems and equipment as indicated in individual specification sections herein. It is preferred that these training sessions for different systems are coordinated to occur on the same day or group of days.

B. Allow Owner to record demonstrations.

END OF SECTION

SECTION 260011
FACILITY PERFORMANCE REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Field conditions and other facility performance requirements applicable to Work specified in Division 26.

1.02 FIELD CONDITIONS

A. Seismic Hazard Design Loads:

1. Unless otherwise indicated on Contract Documents, specified Work must withstand seismic hazard design loads determined in accordance with requirements specified in this Section, adjusted for installed elevation above or below grade.
   a. The term "withstand" means "unit must remain in place without separation of parts from unit when subjected to specified seismic hazard design loads and unit must be fully operational after seismic event."
2. Perform calculations to obtain force information necessary to properly select seismic-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in ASCE/SEI 7-22. Where "ASCE/SEI 7" is used throughout this Section, it must be understood that the edition referred to in this subparagraph is the edition intended as reference throughout the Section Text.
   a. Data indicated below to be determined by Delegated Design Contractor must be obtained by Contractor and must be included in individual component submittal packages.
   b. Coordinate seismic design calculations with wind-load calculations for equipment mounted outdoors.
   c. Building Risk Category: IV.
   d. Building Site Classification: D.
   e. Seismic Design Category C
3. Calculation Factors, ASCE/SEI 7-22, Ch. 13 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-22 unless otherwise indicated.
   a. Horizontal Seismic Design Force F_p: Value must be calculated by Delegated Design Contractor using Equation 13.3-1. Factors below must be obtained for this calculation:
      1) Component Amplification Factor (a_p): Obtain by Delegated design Contractor.
      2) Component Importance Factor (I_p): 1.5.
      3) Component Operating Weight (W_p): For each component. Obtain by Delegated Design Contractor from each component submittal.
      4) Component Response Modification Factor (R_p): ASCE 7 Table 13.6-1.
      5) Height in Structure of Point of Attachment of Component for Base (z): Determine from Project Drawings for each component by Delegated Design Contractor. For items at or below the base, "z" must be taken as zero.
      6) Average Roof Height of Structure for Base (h): Determine from Project Drawings by Delegated Design Contractor.
   b. Vertical Seismic Design Force: Calculated by Delegated Design Contractor using method explained in ASCE/SEI 7-22, Paragraph 13.3.1.6.

c. Seismic Relative Displacement (D_{pl}): Calculated by Delegated Design Contractor using methods explained in ASCE/SEI 7-22, Paragraph 13.3.2. Factors below must be obtained for this calculation:
   1) Relative Seismic Displacement that Each Component Must Be Designed to Accommodate (D_p): Calculated by Delegated Design Contractor in accordance with ASCE/SEI 7-22, Paragraph 13.3.2.
   2) Structure Importance Factor (I_e): 1.5. Value applies to all components on Project.
   3) Story deflection (δ_x): 0.25”
   4) Deflection at Building Level y of Structure B (δ_{yB}): See Drawing Schedule for each component.
   5) Height of Level x to Which Upper Connection Point Is Attached (h_x): Determine for each component by Delegated Design Contractor from Project Drawings and manufacturer's data.
   6) Height of Level y to Which Upper Connection Point Is Attached (h_y): Determine for each component by Delegated Design Contractor from Project Drawings and manufacturer's data.
   7) Allowable Story Drift for Structure A (Δ_{aA}): 1.6”
   8) Story Height Used in the Definition of the Allowable Drift Δ_a (h_{sx}): See Drawings.

d. Component Fundamental Period (T_p): Calculated by Delegated Design Contractor using methods explained in ASCE/SEI 7-22, Paragraph 13.3.3. Factors below must be obtained for this calculation:
   1) Component Operating Weight (W_p): Determined by Contractor from Project Drawings and manufacturer's data.
   2) Gravitational Acceleration (g): 32.17 ft./s2.
   3) Combined Stiffness of the Component, Supports, and Attachments (K_p): Determined by delegated design seismic engineer.

B. Wind Hazard Design Loads:
   1. Perform calculations to obtain force information necessary to properly select wind-load restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in ASCE/SEI 7-22. Where "ASCE/SEI 7" is used throughout this Section, it must be understood that the edition referred to in this subparagraph is intended as referenced throughout the Section Text unless otherwise indicated.
      a. Data indicated below that are specific to individual pieces of equipment must be obtained by Contractor and must be included in individual component submittal packages.
      b. Coordinate design wind-load calculations with seismic-load calculations for equipment requiring both seismic- and wind-load reinforcement. Comply with requirements in other Sections in addition to those in this Section.
   2. Design wind pressure "p" for rooftop equipment must be calculated by Delegated Design Contractor using methods in ASCE/SEI 7-16, Ch. 30, PART 6: Building Appurtenances and Rooftop Structures and Equipment.
      a. Risk Category: IV.
      b. Basic Wind Speed (V): See structural drawings.
      c. Wind Directionality Factor (K_d): See structural drawings.

d. Velocity Pressure at Height z (q_z): Value is calculated by delegated wind-load design Contractor using methods detailed in ASCE/SEI 7-22 Section 26.10 or other source approved by authorities having jurisdiction.

C. Altitude:
   1. Sea level to 1000 ft..

D. Ambient Temperature:
   1. 0 to 120 deg F.

E. Temperature Variation: Allow for thermal movements from the following differential temperatures:
   1. Ambient Temperature Differential: 120 deg F.
   2. Material Surface Temperature Differential: 180 deg F.
   3. Ground Surface Temperature Differential to 10 ft. Depth: .

F. Ground Water:
   1. Assume ground-water level is at grade level unless a lower water table is noted on Drawings.
   2. Assume ground-water level is 36 inch below ground surface unless a higher water table is indicated on Drawings.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION

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SECTION 260519
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Copper building wire.
2. Metal-clad cable, Type MC.
3. Tray cable, Type TC.
4. Fire-alarm wire and cable.
5. Connectors and splices.

B. Related Requirements:
1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.

1.02 ACTION SUBMITTALS

A. Product Data:
1. Copper building wire.
2. Metal-clad cable, Type MC.
3. Tray cable, Type TC.
4. Fire-alarm wire and cable.

1.03 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.01 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Alpha Wire; brand of Belden, Inc.
2. Belden Inc.
3. Cerro Wire LLC.
4. Encore Wire Corporation.
5. General Cable; Prysmian Group North America.
6. Okonite Company (The).
7. Service Wire Co.
8. Southwire Company, LLC.
9. WESCO.

C. Standards:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 or ASTM B496, where applicable for stranded conductors.

E. Conductor Insulation:

1. Type TC-ER. Comply with NEMA WC 70/ICEA S-95-658 and UL 1277.
2. Type THHN and Type THWN-2. Comply with UL 83.
3. Type THW and Type THW-2. Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
4. Type XHHW-2. Comply with UL 44.

F. Shield:
1. Type TC-ER: Cable designed for use with ASDs, with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket.

2.02 METAL-CLAD CABLE, TYPE MC

A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Alpha Wire; brand of Belden, Inc.
2. Belden Inc.
3. Encore Wire Corporation.
4. General Cable; Prysmian Group North America.
5. Okonite Company (The).
6. Southwire Company, LLC.
7. WESCO.

C. Standards:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1569.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Circuits:
1. Single circuit.
2. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.

E. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

F. Ground Conductor: Insulated.

G. Conductor Insulation:
1. Type TFN/THHN/THWN-2. Comply with UL 83.
2. Type XHHW-2. Comply with UL 44.

H. Armor: Steel, interlocked.

I. Jacket: PVC applied over armor.

J. Plenum-rated, where required.

2.03 TRAY CABLE, TYPE TC

A. Description: A factory assembly of insulated current-carrying conductors with or without an equipment grounding conductor in a nonmetallic jacket.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Alpha Wire; brand of Belden, Inc.
2. Belden Inc.
3. Encore Wire Corporation.
4. General Cable; Prysmian Group North America.
5. Okonite Company (The).
6. Southwire Company, LLC.

7. WESCO.

C. Standards:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1277.
3. Comply with ICEA S-73-532/NEMA WC 57 for Type TC cables used for control, thermocouple extension, and instrumentation.
4. Comply with ICEA S-95-658/NEMA WC 70 for Type TC cables used for power distribution.
5. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

E. Ground Conductor: Insulated.

F. Conductor Insulation: Type XHHW-2. Comply with UL 44.

G. Shield: Metallic.

2.04 FIRE-ALARM WIRE AND 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. Allied Wire & Cable Inc.
2. CommScope, Inc.
3. Comtran Corporation.
4. Genesis Cable Products; Honeywell International, Inc.
5. Prysmian Cables and Systems; Prysmian Group North America.
6. Superior Essex Inc.; subsidiary of LS Corp.
7. West Penn Wire; brand of Belden, Inc.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, No. 16 AWG.
1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.
1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

2.05 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. 3M Electrical Products.
2. ABB, Electrification Business.
3. AFC Cable Systems; Atkore International.
4. Gardner Bender.

5. Hubbell Utility Solutions; Hubbell Incorporated.
6. ILSCO.
7. Ideal Industries, Inc.
8. NSi Industries LLC.
9. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
10. Service Wire Co.
11. TE Connectivity Ltd.
12. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.

PART 3 - EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders:

1. Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits:

1. Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. ASD Output Circuits Cable: Extra-flexible stranded for all sizes.

D. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.

E. Feeders in Cable Tray: Type THHN/THWN-2, single conductors in raceway, Type XHHW-2, single conductors in raceway, or Metal-clad cable, Type MC.

F. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway or Metal-clad cable, Type MC.

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.

I. Branch Circuits in Cable Tray: Type XHHW-2, single conductors larger than No. 1/0 AWG or Metal-clad cable, Type MC.

J. Branch circuits in Utility Trench in floor: Type TC-ER cable with braided shield.

K. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless steel, wire-mesh, strain relief device at terminations to suit application.

L. ASD Output Circuits: Type TC-ER cable with braided shield.

3.03 INSTALLATION, GENERAL

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points in accordance with Section 260533.13 "Conduits for Electrical Systems" prior to pulling conductors and cables.
C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."
G. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.04 INSTALLATION OF FIRE-ALARM WIRE AND CABLE

A. Comply with NFPA 72.
B. Wiring Method: Install wiring in metal pathway according to Section 270528.29 "Hangers and Supports for Communications Systems."
   1. Install plenum cable in environmental airspaces, including plenum ceilings.
   2. Fire-alarm circuits and equipment control wiring associated with fire-alarm system must be installed in a dedicated pathway system.
      a. Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.
   3. Fire-Rated Cables: Use of two-hour, fire-rated fire-alarm cables, NFPA 70, Types MI and CI, is permitted.
   4. Signaling Line Circuits: Power-limited fire-alarm cables may be installed in the same cable or pathway as signaling line circuits.
C. 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 fire-alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes; cabinets; or equipment enclosures where circuit connections are made.
E. Color-Coding: Color-code fire-alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another 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 junction boxes and covers red.
F. Risers: Install at least two vertical cable risers to serve the fire-alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent receipt or transmission of signals from other floors or zones.
G. Wiring to Remote Alarm Transmitting Device: 1 inch conduit between the fire-alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.05 CONNECTIONS

A. 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-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inch of slack.

D. Comply with requirements in Section 284621.11 "Addressable Fire-Alarm Systems" for connecting, terminating, and identifying wires and cables.

3.06 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.07 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 Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.08 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.09 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors and conductors feeding the following critical equipment and services for compliance with requirements:
   a. Welding equipment.
   b. CNC lab equipment.
   c. NDT lab equipment
   d. AM Lab equipment.
   e. Harmonic filter equipment.
   f. Circuitry to Chillers and AHU’s.
2. Perform each of the following visual and electrical tests:
   a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
   b. Test bolted connections for high resistance using one of the following:
      1) A low-resistance ohmmeter.
      2) Calibrated torque wrench.
      3) Thermographic survey.
   c. Inspect compression-applied connectors for correct cable match and indentation.
   d. Inspect for correct identification.
   e. Inspect cable jacket and condition.
   f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable for a one-minute duration.
   g. Continuity test on each conductor and cable.
   h. Uniform resistance of parallel conductors.

3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
    a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

B. Cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports to record the following:
1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION

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SECTION 260523
CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Category 5e balanced twisted pair cable.
   2. Category 6 balanced twisted pair cable.
   3. Balanced twisted pair cable hardware.
   4. RS-232 cable.
   5. RS-485 cable.
   6. Control cable.
   7. Control-circuit conductors.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

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. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
   1. Flame Travel Distance: 60 inch or less.
   2. Peak Optical Smoke Density: 0.5 or less.
   3. Average Optical Smoke Density: 0.15 or less.

C. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

D. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.02 CATEGORY 5e BALANCED TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 5e cable at frequencies up to 100 MHz.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Belden Inc.
   2. CommScope, Inc.
   3. General Cable; Prysmian Group North America.
   4. Hitachi Cable America Inc.
   5. Mohawk; a division of Belden Networking, Inc.
   6. West Penn Wire; brand of Belden, Inc.

C. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 5e cables.

D. Conductors: 100 ohm, No. 24 AWG solid copper.

E. Jacket: thermoplastic. Coordinate color with owner.

F. Plenum-rated, where required.

2.03 CATEGORY 6 BALANCED TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 6 cable at frequencies up to 250 MHz.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. 3M.
   2. Belden Inc.
   3. CommScope, Inc.
   4. General Cable; Prysmian Group North America.
   5. Genesis Cable Products; Honeywell International, Inc.
   6. Hitachi Cable America Inc.
   7. Mohawk; a division of Belden Networking, Inc.
   8. Prysmian Cables and Systems; Prysmian Group North America.
   9. Superior Essex Inc.; subsidiary of LS Corp.

C. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.

D. Conductors: 100 ohm, No. 23 AWG solid copper.

E. Jacket: Thermoplastic. Coordinate color with owner.

F. Plenum-rated, where required.

2.04 BALANCED TWISTED PAIR CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate balanced twisted pair copper communications cable.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. 3M.
   2. Belden Inc.
   3. CommScope, Inc.
   4. General Cable; Prysmian Group North America.
   5. Genesis Cable Products; Honeywell International, Inc.
   6. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   7. Leviton Manufacturing Co., Inc.

C. General Requirements for Balanced Twisted Pair Cable Hardware:
   1. Comply with the performance requirements of Category 5e or Category 6, as applicable.
   2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
   3. Cables must be terminated with connecting hardware of same category or higher.

D. Source Limitations: Obtain balanced twisted pair cable hardware from single source from single manufacturer.

E. Connecting Blocks: 110-style IDC for Category 5e, 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. Plugs and Plug Assemblies:
   1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair 100 ohm unshielded or shielded balanced twisted pair cable.
   2. Comply with IEC 60603-7-1, IEC 60603-7-2, IEC 60603-7-3, IEC 60603-7-4, and IEC 60603-7.5.
   3. Marked to indicate transmission performance.

G. 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 patch panel or faceplate.
   3. Standards:
      a. Category 5e, unshielded balanced twisted pair cable must comply with IEC 60603-7-2.
      b. Category 5e, shielded balanced twisted pair cable must comply with IEC 60603-7-3.
      c. Category 6, unshielded balanced twisted pair cable must comply with IEC 60603-7-4.
      d. Category 6, shielded balanced twisted pair cable must comply with IEC 60603-7.5.
   4. Marked to indicate transmission performance.

H. Legend:
   1. Machine printed, in the field, using adhesive-tape label.
   2. Snap-in, clear-label covers and machine-printed paper inserts.

2.05 RS-232 CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Allied Wire & Cable Inc.
   2. Belden Inc.
   3. General Cable; Prysmian Group North America.
   4. Genesis Cable Products; Honeywell International, Inc.
   5. Southwire Company, LLC.

B. PVC-Jacketed, TIA 232-F:
   1. Nine, No. 22 AWG, stranded (7x30) tinned copper conductors.
   2. Polypropylene insulation.
   3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
   4. PVC jacket.
   5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
   6. NFPA 70 Type: Type CM.
   7. Flame Resistance: Comply with UL 1581.

C. Plenum-Type, TIA 232-F:
   1. Nine, No. 22 AWG, stranded (7x30) tinned copper conductors.
   2. PE insulation.
   3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
   4. Fluorinated ethylene propylene jacket.
   5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
   6. Flame Resistance: Comply with NFPA 262.

2.06 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CMG.
   1. Paired, one pair, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
   2. PVC insulation.
   3. Unshielded.
   4. PVC jacket.
   5. Flame Resistance: Comply with UL 1685.

B. Plenum-Rated Cable: NFPA 70, Type CMP.
   1. Paired, one pair, No. 22 AWG, stranded (7x30) tinned-copper conductors.
   2. Fluorinated ethylene propylene insulation.
   3. Unshielded.
   4. Fluorinated ethylene propylene jacket.
   5. Flame Resistance: NFPA 262.

2.07 CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMG.
   1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
   2. PVC insulation.
   3. Unshielded.
   4. PVC jacket.
   5. Flame Resistance: Comply with UL 1685.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
   1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
   2. PVC insulation.
   3. Unshielded.
   4. PVC jacket.
   5. Flame Resistance: Comply with NFPA 262.

2.08 CONTROL-CIRCUIT CONDUCTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Encore Wire Corporation.
   2. General Cable; Prysmian Group North America.
   3. Service Wire Co.
   4. Southwire Company, LLC.

B. Class 1 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway, Type TC, complying with UL 1277 in raceway, or Type MC, complying with UL 1569.

C. Class 2 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

D. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

2.09 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test twisted pair cables according to TIA-568-C.2.

C. Cable will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Test cables on receipt at Project site.
   1. Test each pair of twisted pair cable for open and short circuits.

3.02 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" for raceway selection and installation requirements for conduits as supplemented or modified in this Section.

B. Comply with requirements in Section 260533.23 "Surface Raceways for Electrical Systems" for raceway selection and installation requirements for wireways as supplemented or modified in this Section.

C. Comply with requirements in Section 260533.16 "Boxes and Covers for Electrical Systems" for raceway selection and installation requirements for boxes as supplemented or modified in this Section.
   1. Outlet boxes must be no smaller than 2 inch wide, 3 inch high, and 2-1/2 inch deep.
   2. Flexible metal conduit must not be used.
D. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.
E. Install manufactured conduit sweeps and long-radius elbows if possible.
F. Raceway Installation in Equipment Rooms:
   1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
   2. Install cable trays to route cables if conduits cannot be located in these positions.
   3. Secure conduits to backboard if entering the room from overhead.
   4. Extend conduits 3 inch above finished floor.
   5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.
B. General Requirements for Cabling:
   1. Comply with TIA-568-C Series of standards.
   2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
   3. Terminate all conductors; cable must not contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
   4. Cables may not be spliced and must be continuous from terminal to terminal. Do not splice cable between termination, tap, or junction points.
   5. Cables serving a common system may be grouped in a common raceway. Install network cabling and control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
   6. Secure and support cables at intervals not exceeding 30 inch and not more than 6 inch from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
   8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
   9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
   10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
   11. Support: Do not allow cables to lie on removable ceiling tiles.
   12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
   13. Provide strain relief.
   14. Keep runs short. Allow extra length for connecting to terminals. Do not bend cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect

cables from vibration at points where they pass around sharp corners and through penetrations.

15. Ground wire must be copper, and grounding methods must comply with IEEE C2. Demonstrate ground resistance.

C. Balanced Twisted Pair Cable Installation:
   1. Comply with TIA-568-C.2.
   2. Install termination hardware as specified in Section 271513 "Communications Copper Horizontal Cabling" unless otherwise indicated.
   3. Do not untwist balanced twisted pair cables more than 1/2 inch at the point of termination to maintain cable geometry.

D. Installation of Control-Circuit Conductors:
   1. Install wiring in raceways.
   2. Use insulated spade lugs for wire and cable connection to screw terminals.

E. Open-Cable Installation:
   1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
   2. Suspend copper cable not in a wireway or pathway a minimum of 8 inch above ceilings by cable supports not more than 30 inch apart.
   3. Cable must not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

F. Separation from EMI Sources:
   1. Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.
   2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment must be as follows:
      a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 5 inch.
      b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 12 inch.
      c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 24 inch.
   3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment must be as follows:
      a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 2-1/2 inch.
      b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 6 inch.
      c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 12 inch.
   4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures must be as follows:
      a. Electrical Equipment or Circuit Rating Less Than 2 kVA: No requirement.
      b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 3 inch.
      c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 6 inch.
   5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inch.
   6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inch.

3.04 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:
   1. Class 1 remote-control and signal circuits; No 14 AWG.

2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG.

3.05 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."
B. Comply with TIA-569-D, Annex A, "Firestopping."
C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.06 GROUNDING

A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
B. For control-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.07 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
B. Identify data and communications system components, wiring, and cabling according to TIA-606-B; label printers must use label stocks, laminating adhesives, and inks complying with UL 969.
C. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire must have a unique tag.

3.08 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Visually inspect cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
   2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
B. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
C. End-to-end cabling will be considered defective if it does not pass tests and inspections.
D. Prepare test and inspection reports.

END OF SECTION

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SECTION 260526
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Grounding and bonding conductors.
   2. Grounding and bonding clamps.
   3. Grounding and bonding bushings.
   4. Grounding and bonding hubs.
   5. Grounding and bonding connectors.
   6. Intersystem bonding bridge grounding connector.
   7. Grounding and bonding busbars.
   8. Grounding (earthing) electrodes.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" specifies seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
   3. Section 264113 "Lightning Protection for Structures" specifies bonding of lightning protection grounding electrodes to facility grounding electrodes.

1.02 ACTION SUBMITTALS

A. Product Data:
   1. For each type of product indicated.

B. Shop Drawings: Plans showing dimensioned locations of grounding features described in "Field Quality Control" Article, including the following:
   1. Test wells.
   2. Rod electrodes.
   3. Grounding arrangements and connections for separately derived systems.

C. Field Quality-Control Submittals:
   1. Field quality-control reports.

1.03 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:
   1. In addition to items specified in Section 260010 "Supplemental Requirements for Electrical," include the following:
      a. Plans showing locations of grounding features described in "Field Quality Control" Article, including the following:
         1) Test wells.
         2) Rod electrodes.
         3) Grounding arrangements and connections for separately derived systems.
      b. Instructions for periodic testing and inspection of grounding features at test wells and grounding connections for separately derived systems based on NFPA 70B.
         1) Tests must determine if ground-resistance or impedance values remain within specified maximums, and instructions must recommend corrective action if values do not.

PART 2 - PRODUCTS

2.01 GROUNDING AND BONDING CONDUCTORS

A. Equipment Grounding Conductor:

1. General Characteristics: 600 V, THHN/THWN-2 or THWN-2, copper wire or cable, green color, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Isolated Equipment Grounding Conductor:
   1. General Characteristics: 600 V, THHN/THWN-2 or THWN-2, copper wire or cable, green color with one or more yellow stripes, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. ASTM - Bare Copper Grounding and Bonding Conductor:
   1. Referenced Standards: Complying with one or more of the following:
      a. Soft or Annealed Copper Wire: ASTM B3
      b. Concentric-Lay Stranded Copper Conductor: ASTM B8.
      c. Tin-Coated Soft or Annealed Copper Wire: ASTM B33.
      d. 19-Wire Combination Unilay-Stranded Copper Conductor: ASTM B787/B787M.

D. UL KDER - Armored Grounding Wire:
   1. Description: Single corrosion-resistant copper, aluminum, or copper-clad aluminum conductor within helically formed steel armor.
   2. Regulatory Requirements:
      a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   3. Listing Criteria:
      a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

E. UL KDSH - Protector Grounding Conductor:
   1. Description: Conductors intended to be used for grounding primary protector or metallic members of cable sheath in accordance with Chapters 7 and 8 of NFPA 70.
   2. Regulatory Requirements:
      a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   3. Listing Criteria:
      a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
   4. Options:
      a. Color: Light olive gray or green.

2.02 GROUNDING AND BONDING CLAMPS

A. Description: Clamps suitable for attachment of grounding and bonding conductors to grounding electrodes, pipes, tubing, and rebar. Grounding and bonding clamps specified in this article are also suitable for use with communications applications; see Section 270526 "Grounding and Bonding for Communications Systems," for selection and installation guidelines.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:
   1. Regulatory Requirements:
      a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria:
      a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

D. UL KDER and KDSH - Hex-Fitting-Type Pipe and Rod Grounding and Bonding Clamp
1. General Characteristics:
a. Two pieces with stainless steel bolts.
b. Clamp Material: Silicon bronze.
c. Listed for outdoor use.

E. UL KDER and KDSH - U-Bolt-Type Pipe and Rod Grounding and Bonding Clamp
1. General Characteristics:
a. Clamp Material: Brass.
b. Listed for outdoor use.

F. UL KDER and KDSH - Strap-Type Pipe and Rod Grounding and Bonding Clamp
1. General Characteristics:
a. Clamp Material: Galvanized steel.
b. Listed for outdoor use.

G. UL KDER - Beam Grounding and Bonding Clamp
1. General Characteristics: Mechanical-type, terminal, ground wire access from four directions; with dual, tin-plated or silicon bronze bolts.

H. UL KDER - Exothermically Welded Connection
1. General Characteristics: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.03 GROUNDING AND BONDING BUSHINGS

A. Description: Bonding bushings connect conduit fittings, tubing fittings, threaded metal conduit, and unthreaded metal conduit to metal boxes and equipment enclosures, and have one or more bonding screws intended to provide electrical continuity between bushing and enclosure. Grounding bushings have provision for connection of bonding or grounding conductor and may or may not also have bonding screws.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:
1. Regulatory Requirements:
a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

D. UL KDER - Bonding Bushing
1. General Characteristics: Threaded bushing with insulated throat.

E. UL KDER - Grounding Bushing
1. General Characteristics: Threaded bushing with insulated throat and mechanical-type wire terminal.

2.04 GROUNDING AND BONDING HUBS

A. Description: Hubs with certified grounding or bonding locknut.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:
1. Regulatory Requirements:
a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:

a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

D. UL KDER - Grounding and Bonding Hub
1. General Characteristics: Insulated, gasketed, watertight hub with mechanical-type wire terminal.

2.05 GROUNDING AND BONDING CONNECTORS

A. Source Limitations: Obtain products from single manufacturer.

B. Performance Criteria:
1. Regulatory Requirements:
a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

C. UL KDER - Pressure-Type Grounding and Bonding Busbar Cable Connector
1. General Characteristics: Copper or copper alloy, for compression bonding of one or more conductor directly to copper busbar. Listed for direct burial.

D. UL KDER - Lay-In Lug Mechanical-Type Grounding and Bonding Busbar Terminal
1. General Characteristics: Mechanical-type, copper rated for direct burial terminal with set screw.

E. UL KDER - Crimped Lug Pressure-Type Grounding and Bonding Busbar Terminal
1. General Characteristics: Cast silicon bronze, solderless compression-type wire terminals; with long barrel and two holes spaced on 5/8 or 1 inch centers for two-bolt connection to busbar.

F. UL KDER - Split-Bolt Service-Post Pressure-Type Grounding and Bonding Busbar Terminal
1. General Characteristics: Bolts that surround cable and bond to cable under compression when nut is tightened after assembly is screwed into busbar opening.

G. UL KDER - Crimped Pressure-Type Grounding and Bonding Cable Connector
1. General Characteristics: Crimp-and-compress connectors that bond to conductor when connector is compressed around conductor.
a. Copper, C and H shaped.

H. UL KDER - Split-Bolt Pressure-Type Grounding and Bonding Cable Connector
1. General Characteristics: Bolts that surround cable and bond to cable under compression when nut is tightened.
a. Copper.

I. UL KDER - Signal Reference Grid Grounding and Bonding Connector
1. General Characteristics: Combination of compression wire connectors, access floor grounding clamps, bronze U-bolt grounding clamps, and copper split-bolt connectors, designed for the purpose.

2.06 INTERSYSTEM BONDING BRIDGE GROUNDING CONNECTORS

A. Description: Devices that provide means for connecting communications systems grounding and bonding conductors at service equipment or at disconnecting means for buildings or structures.

B. Performance Criteria:
1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. Listing Criteria:

a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

C. UL KDSH - One-Piece Intersystem Bonding Bridge Grounding Connector:

1. General Characteristics: Zinc-alloy one-piece construction; six terminating points; gangable.

D. UL KDSH - Two-Piece Intersystem Bonding Bridge Grounding Connector:

1. General Characteristics: Copper body and polycarbonate cover; four terminating points.

2.07 GROUNDING AND BONDING BUSBARS

A. Description: Miscellaneous grounding and bonding device that serves as common connection for multiple grounding and bonding conductors.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. Listing Criteria:

a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

D. UL KDER - Equipment Room Grounding and Bonding Busbar

1. General Characteristics:

a. Bus: Rectangular bar of annealed copper.

b. Mounting Stand-Off Insulators: Lexan or PVC.

1) Comply with UL 891 for use in 600 V switchboards, impulse tested at 5000 V.

2. Options:

a. Dimensions: 1/4 by 8 inch in cross section; length as indicated on Drawings.

b. Predrilled Hole Pattern: 9/32 inch holes spaced 1-1/8 inch apart.

c. Mounting Hardware: Stand-off brackets that provide 2 inch clearance to access rear of bus. Brackets and bolts must be stainless steel.

E. UL KDER - Rack and Cabinet Bonding Busbar

1. General Characteristics:

a. Bus: Rectangular bar of hard-drawn solid copper.

b. Horizontal Mounting Dimensions: Designed for mounting in size equipment racks or cabinets specified by Owner.

c. Vertical Mounting Dimensions: Designed for mounting in 72 inch high equipment racks or cabinets.

d. Predrilled Hole Pattern: Accepts connectors for grounding and bonding conductor sizes 14 AWG to 2/0 AWG.

e. Mounting Hardware: Stainless steel or copper-plated, for attachment to rack.

2.08 GROUNDING (EARTHING) ELECTRODES

A. Description: Grounding electrodes include rod electrodes, ring electrodes, metal underground water pipes, metal building frames, concrete-encased electrodes, and pipe and plate electrodes.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:
   1. Regulatory Requirements:
      a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria:
      a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

D. UL KDER - Rod Electrode :
   1. General Characteristics: Copper-clad steel; 3/4 inch by 10 ft.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine facility's grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of electrical system.

B. Inspect test results of grounding system measured at point of electrical service equipment connection.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of electrical service equipment only after unsatisfactory conditions have been corrected.

3.02 SELECTION OF BUSBARS

A. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Install bus horizontally, on insulated spacers 2 inch minimum from wall, 6 inch above finished floor unless otherwise indicated.
   2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

3.03 SELECTION OF GROUNDING AND BONDING CONDUCTORS

A. Conductors: Install solid conductor for 8 AWG and smaller, and stranded conductors for 6 AWG and larger unless otherwise indicated.

B. Custom-Length Insulated Equipment Bonding Jumpers: 6 AWG, 19-strand, Type THHN.

C. Bonding Cable: 28 kcmil, 14 strands of 17 AWG conductor, 1/4 inch in diameter.

D. Bonding Conductor: 4 AWG or 6 AWG, stranded conductor.

E. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.

3.04 SELECTION OF CONNECTORS

A. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
   3. Connections to Ground Rods at Test Wells: Bolted connectors.
   4. Connections to Structural Steel: Welded connectors.

3.05 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Reference Standards:
   1. Ground Bonding Common 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.

2. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:

1. Conductors:
   a. 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.
2. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
   a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
   b. Make connections with clean, bare metal at points of contact.
   c. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
   d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
   e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
   f. 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 adjacent parts.
      2) Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
      3) Use exothermic-welded connectors for outdoor locations; if disconnect-type connection is required, use bolted clamp.
   g. 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; use bolted clamp connector or bolt lug-type connector to pipe flange by using one of lug bolts of flange. Where 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 bolted connector.
      3) Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
   h. 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.
   i. Grounding for Steel Building Structure: Install driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft apart.
3. Electrodes:

a. Ground Rods: Drive rods until tops are 2 inch below finished floor or final grade unless otherwise indicated.
   1) Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
   2) Use exothermic welds for below-grade connections.
b. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and must be at least 12 inch deep, with cover.
c. Concrete-Encased Electrode (Ufer Ground):
   1) Fabricate in accordance with NFPA 70; use minimum of 20 ft of bare copper conductor not smaller than 4 AWG.
      a) 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.
   2) Fabricate in accordance with NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 ft long. If reinforcing is in multiple pieces, connect together by usual steel tie wires or exothermic welding to create required length.

4. Grounding at Service:
   a. Equipment grounding conductors and grounding electrode conductors must be connected to ground bus. Install main bonding jumper between neutral and ground buses.
5. Grounding Separately Derived Systems:
   a. Generator: Install grounding electrode(s) at generator location. Electrode must be connected to equipment grounding conductor and to frame of generator.
6. Grounding Underground Distribution System Components:
   a. Duct-Bank Grounding Conductor: Bury 12 inch above duct bank when indicated as part of duct-bank installation.
   b. Comply with IEEE C2 grounding requirements.
   c. Grounding Manholes and Handholes: Install driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inch will extend above finished floor. If necessary, install ground rod before manhole is placed and provide 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inch above to 6 inch below concrete. Seal floor opening with waterproof, nonshrink grout.
   d. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields in accordance with manufacturer's published instructions with splicing and termination kits.
   e. Pad-Mounted Transformers and Switches: Install two ground rods and ring electrode around pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable

and grounding electrodes. Install tinned-copper conductor not less than 2 AWG for ring electrode and for taps to equipment grounding terminals. Bury ring electrode not less than 6 inch from foundation.

7. Equipment Grounding:
   a. Install insulated equipment grounding conductors with feeders and branch circuits.
   b. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
      1) Feeders and branch circuits.
      2) Lighting circuits.
      3) Receptacle circuits.
      4) Single-phase motor and appliance branch circuits.
      5) Three-phase motor and appliance branch circuits.
      6) Flexible raceway runs.
      7) Armored and metal-clad cable runs.
      8) Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
   c. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
   d. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
   e. Isolated Grounding Receptacle Circuits: Install insulated equipment grounding conductor connected to receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of applicable derived system or service unless otherwise indicated.
   f. Isolated Equipment Enclosure Circuits: For designated equipment supplied by branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of applicable derived system or service unless otherwise indicated.
   g. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.06 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
   2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench in accordance with manufacturer's published instructions.
   3. Test completed grounding system at each location where maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and

at individual ground rods. Make tests at ground rods before conductors are connected.

a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
b. Perform tests by fall-of-potential method in accordance with IEEE Std 81.
c. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

4. 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 record of tests and observations. Include 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. Nonconforming Work:
1. Grounding system will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective components and retest.

C. Collect, assemble, and submit test and inspection reports.
1. Report measured ground resistances that exceed the following values:
a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 Ω.
b. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 Ω.
c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 Ω.
d. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 Ω.
e. Substations and Pad-Mounted Equipment: 5 Ω.
f. Manhole Grounds: 10 Ω.

3.07 PROTECTION

A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION

SECTION 260529
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Support, anchorage, and attachment components.
   2. Fabricated metal equipment support assemblies.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.02 ACTION SUBMITTALS

A. Product Data:
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
      a. Slotted support systems, hardware, and accessories.
      b. Hangers.
      c. Brackets.
   2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.
   1. Hangers. Include product data for components.
   2. Slotted support systems.
   3. Equipment supports.

C. Delegated Design Submittals: For hangers and supports for electrical systems.
   1. Include design calculations and details of hangers.
   2. Include design calculations for seismic restraints.

PART 2 - PRODUCTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32 inch diameter holes at a maximum of 8 inch on center in at least one surface.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ABB, Electrification Business.
      b. Allied Tube & Conduit; Atkore International.
      c. CADDY; brand of nVent Electrical plc.
      d. Cooper B-line; brand of Eaton, Electrical Sector.
      e. Flex-Strut Inc.
      f. G-Strut.
      g. Rocket Rack; Robroy Industries.
   2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
   3. Material for Channel, Fittings, and Accessories: Galvanized steel.
   4. Channel Width: Selected for applicable load criteria.
   5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs must have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body must be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

E. 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.
2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325.
6. Toggle Bolts: Stainless steel springhead type.
7. Hanger Rods: Threaded steel.

2.02 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 Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.01 SELECTION

A. Comply with the following standards for selection and installation of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA NEIS 101
2. NECA NEIS 105.

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways specified in Section 260533.13 "Conduits for Electrical Systems."

D. Comply with requirements for boxes specified in Section 260533.16 "Boxes and Covers for Electrical Systems."

E. Provide vibration and seismic controls with hangers and supports in accordance with requirements specified in "Section 260548 "Vibration and Seismic Controls for Electrical Systems."

F. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERMC as required by NFPA 70. Minimum rod size must be 1/4 inch in diameter.

G. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other 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 two-bolt conduit clamps single-bolt conduit clamps single-bolt conduit clamps using spring friction action for retention in support channel.

3.02 INSTALLATION OF SUPPORTS

A. Comply with NECA NEIS 101 for installation requirements except as specified in this article.

B. 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 must be weight of supported components plus 200 lb.

C. 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 inch thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inch thick.
   6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
   7. To Light 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 by means that comply with seismic-restraint strength and anchorage requirements.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "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. Submit welding certificates.

3.04 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 inch larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000 psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

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 anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.05 PAINTING

A. Touchup:

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

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION

SECTION 260533.13
CONDUITS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Type EMT-S duct raceways and elbows.
   2. Type ERMC-S duct raceways, elbows, couplings, and nipples.
   3. Type FMC-S and Type FMC-A duct raceways.
   4. Type LFMC duct raceways.
   5. Type PVC duct raceways and fittings.
   6. Fittings for conduit, tubing, and cable.
   7. Electrically conductive corrosion-resistant compounds for threaded conduit.
   8. Solvent cements.

B. Products Installed, but Not Furnished, under This Section:
   1. See Section 260553 "Identification for Electrical Systems" for electrical equipment labels.

C. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
   3. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior duct banks, manholes, and underground utility construction.

1.02 DEFINITIONS

A. Conduit: A structure containing one or more duct raceways.

B. Duct Raceway: A single enclosed raceway for conductors or cable.

C. Duct Bank: An arrangement of conduit providing one or more continuous duct raceways between two points.

1.03 ACTION SUBMITTALS

A. Product Data:
   1. Type EMT-S duct raceways and elbows.
   2. Type ERMC-S duct raceways, elbows, couplings, and nipples.
   3. Type FMC-S and Type FMC-A duct raceways.
   4. Type LFMC duct raceways.
   5. Type PVC duct raceways and fittings.
   6. Fittings for conduit, tubing, and cable.

PART 2 - PRODUCTS

2.01 TYPE EMT-S DUCT RACEWAYS AND ELBOWS

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria: UL CCN FJMX; including UL 797.

B. Source Quality Control:
   1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.

2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL FJMX - Steel Electrical Metal Tubing (EMT-S) and Elbows:
1. Material: Steel.
2. Options:
a. Exterior Coating: Zinc.
b. Interior Coating: Zinc with organic top coating.
c. Minimum Trade Size: Metric designator 21 (trade size 3/4).
d. Colors: Standard unless where indicated on drawings to be black. In these areas, black conduit may be provided or paintable conduit, if painted by the General Contractor.

2.02 TYPE ERMC-S DUCT RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria: UL CCN DYIX; including UL 6.

B. Source Quality Control:
1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DYIX - Galvanized-Steel Electrical Rigid Metal Conduit (ERMC-S-G), Elbows, Couplings, and Nipples:
1. Exterior Coating: Zinc.
2. Options:
a. Interior Coating: Zinc with organic top coating.
b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
c. Colors: Standard unless where indicated on drawings to be black. In these areas, black conduit may be provided or paintable conduit, if painted by the General Contractor.

2.03 TYPE FMC-S DUCT RACEWAYS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria: UL CCN DXUZ; including UL 1.

B. Source Quality Control:
1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DXUZ - Steel Flexible Metal Conduit (FMC-S):
1. Material: Steel.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
b. Colors: Standard unless where indicated on drawings to be black. In these areas, black conduit may be provided or paintable conduit, if painted by the General Contractor.

2.04 TYPE IMC DUCT RACEWAYS

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria: UL CCN DYBY; including UL 1242.

B. Source Quality Control:
   1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
   2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DYBY - Steel Intermediate Metal Conduit (IMC):
   1. Options:
      a. Exterior Coating: Zinc.
      b. Interior Coating: Zinc with organic top coating.
      c. Minimum Trade Size: Metric designator 21 (trade size 3/4).
      d. Colors: Standard unless where indicated on drawings to be black. In these areas, black conduit may be provided or paintable conduit, if painted by the General Contractor.

2.05 TYPE LFMC DUCT RACEWAYS

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria: UL CCN DXHR; including UL 360.

B. Source Quality Control:
   1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
   2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DXHR - Steel Liquidtight Flexible Metal Conduit (LFMC-S):
   1. Material: Steel.
   2. Options:
      a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
      b. Colors: Standard unless where indicated on drawings to be black. In these areas, black conduit may be provided or paintable conduit, if painted by the General Contractor.

2.06 TYPE PVC DUCT RACEWAYS AND FITTINGS

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria: UL CCN DZYR; including UL 651.

B. Source Quality Control:
   1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
   2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DZYR - Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:

1. Dimensional Specifications: Schedule 40.
2. Options:
   a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
   b. Markings: For use with maximum 90 deg C wire.

2.07 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

B. Source Quality Control:
   1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
   2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DWTT - Fittings for Type ERMC, Type IMC, Type PVC:
   1. Listing Criteria: UL CCN DWTT; including UL 514B.
   2. Options:
      a. Material: Steel.
      b. Coupling Method: Compression coupling.
      c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.

D. UL FKAV - Fittings for Type EMT Duct Raceways:
   1. Listing Criteria: UL CCN FKAV; including UL 514B.
   2. Options:
      a. Material: Steel or Die cast.
      b. Coupling Method: Compression coupling.
      c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.

E. UL ILNR - Fittings for Type FMC Duct Raceways:
   1. Listing Criteria: UL CCN ILNR; including UL 514B.

F. UL DXAS - Fittings for Type LFMC and Type LFNC Duct Raceways:
   1. Listing Criteria: UL CCN DXAS; including UL 514B.

2.08 ELECTRICALLY CONDUCTIVE CORROSION-RESISTANT COMPOUNDS FOR THREADED CONDUIT

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria: UL CCN FOIZ; including UL Subject 2419.

B. Source Quality Control:
   1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
   2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

2.09 SOLVENT CEMENTS

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria: UL CCN DWTT; including UL 514B.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

PART 3 - EXECUTION

3.01 SELECTION OF CONDUITS FOR ELECTRICAL SYSTEMS

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NFPA 70 for selection of duct raceways. Consult Architect for resolution of conflicting requirements.

B. Outdoors:
1. Exposed and Subject to Severe Physical Damage: ERMC.
2. Exposed and Subject to Physical Damage: ERMC or IMC.
   a. Locations more than 2.5 m (8 ft) above finished floor.
3. Exposed and Not Subject to Physical Damage: ERMC or IMC.
4. Concealed Aboveground: ERMC or IMC.
5. Direct Buried: PVC-40.
6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.

C. Indoors:
1. Exposed and Subject to Severe Physical Damage: ERMC. Locations include the following:
   a. Loading docks.
   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   c. Mechanical rooms.
   d. High bay spaces (such as Radio Shop)
   e. All Lab spaces
2. Exposed and Subject to Physical Damage: ERMC or IMC. Locations include the following:
   a. Locations more than 12 ft above finished floor.
3. Exposed and Not Subject to Physical Damage: ERMC or IMC.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Damp or Wet Locations: ERMC or IMC.
6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC.

D. Duct Fittings: Select fittings in accordance with NEMA FB 2.10 guidelines.
1. ERMC and IMC: Provide threaded-type fittings unless otherwise indicated.

3.02 INSTALLATION OF CONDUITS FOR ELECTRICAL SYSTEMS

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
1. Type EMT-S: Article 358 of NFPA 70 and NECA NEIS 101.
2. Type ERMC-A: Article 344 of NFPA 70 and NECA NEIS 102.
3. Type ERMC-S: Article 344 of NFPA 70 and NECA NEIS 101.
4. Type FMC-S: Article 348 of NFPA 70 and NECA NEIS 101.
5. Type IMC: Article 342 of NFPA 70 and NECA NEIS 101.
6. Type LFMC: Article 350 of NFPA 70 and NECA NEIS 101.
7. Type PVC: Article 356 of NFPA 70 and NECA NEIS 111.
8. Expansion Fittings: NEMA FB 2.40.

9. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. General Requirements for Installation of Duct Raceways:

a. Complete duct raceway installation before starting conductor installation.

b. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Plug coupling until conduit is extended above floor to final destination or a minimum of 2 ft above finished floor.

c. Install no more than equivalent of three 90-degree bends in conduit run except for control wiring conduits, for which no more than equivalent of two 90-degree fewer bends are permitted. Support within 12 inch of changes in direction.

d. Make bends in duct raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.

e. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

f. Support conduit within 12 inch of enclosures to which attached.

g. Install duct sealing fittings at accessible locations in accordance with NFPA 70 and fill them with listed sealing compound. For concealed duct raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install duct sealing fittings in accordance with NFPA 70.

h. Install devices to seal duct raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal interior of duct raceways at the following points:

1) Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.

2) Where an underground service duct raceway enters a building or structure.

3) Conduit extending from interior to exterior of building.

4) Conduit extending into pressurized duct raceway and equipment.

5) Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.

6) Where otherwise required by NFPA 70.

i. Do not install duct raceways or electrical items on "explosion-relief" walls or rotating equipment.

j. Do not install conduits within 2 inch of the bottom side of a metal deck roof.

k. Keep duct raceways at least 6 inch away from parallel runs of flues and steam or hot-water pipes. Install horizontal duct raceway runs above water and steam piping.

l. Cut conduit perpendicular to the length. For conduits metric designator 53 (trade size 2) and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.

m. Install pull wires in empty duct raceways. Provide polypropylene or monofilament plastic line with not less than 200 lb tensile strength. Leave at least 12 inch of slack at both ends of pull wire. Cap underground duct raceways designated as spare above grade alongside duct raceways in use.

n. Install duct raceways square to the enclosure and terminate at enclosures without hubs with locknuts on both sides of enclosure wall. Install locknuts hand tight, plus one-quarter turn more.

1) Termination fittings with shoulders do not require two locknuts.

o. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to metric designator 35 (trade size 1-1/4) and insulated throat metal bushings on metric designator 41 (trade size 1-1/2) and larger conduits terminated with locknuts..

2. Types ERMC and IMC:
   a. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of duct raceway and fittings before making up joints. Follow compound manufacturer's published instructions.
3. Types FMC, LFMC:
   a. Provide a maximum of 72 inch of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
4. Types PVC:
   a. Do not install Type PVC, Type HDPE, or Type EPEC conduit where ambient temperature exceeds 122 deg F. Conductor ratings must be limited to 75 deg C except where installed in a trench outside buildings with concrete encasement, where 90 deg C conductors are permitted.
   b. Comply with manufacturer's published instructions for solvent welding and fittings.
5. Duct Raceways Embedded in Slabs:
   a. Run duct raceways larger than metric designator 27 (trade size 1) below concrete slab.
   b. Arrange duct raceways to cross building expansion joints with expansion fittings at right angles to the joint.
   c. Arrange duct raceways to ensure that each is surrounded by minimum of 1 inch of concrete without voids.
   d. Do not embed threadless fittings in concrete unless locations have been specifically approved by Architect.
6. Stub-ups to Above Recessed Ceilings:
   a. Provide EMT, IMC, or ERMC for duct raceways.
   b. Provide a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
7. Duct Raceway Terminations at Locations Subject to Moisture or Vibration:
   a. Provide insulating bushings to protect conductors, including conductors smaller than 4 AWG..
8. Duct Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines.
   a. EMT: Provide compression, steel or cast-metal fittings. Comply with NEMA FB 2.10.
   b. Flexible Conduit: Provide only fittings listed for use with flexible conduit type. Comply with NEMA FB 2.20.
9. Expansion-Joint Fittings:
   a. Install in runs of aboveground PVC that are located where environmental temperature change may exceed 30 deg F and that have straight-run length that exceeds 25 ft. Install in runs of aboveground ERMC conduit that are located where environmental temperature change may exceed 100 deg F and that have straight-run length that exceeds 100 ft.
   b. Install type and quantity of fittings that accommodate temperature change listed for the following locations:

1) Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
2) Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
3) Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
4) Attics: 135 deg F temperature change.

c. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.

d. Install expansion fittings at locations where conduits cross building or structure expansion joints.

e. Install expansion-joint fitting with position, mounting, and piston setting selected in accordance with manufacturer's published instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

10. Duct Raceways Penetrating Rooms or Walls with Acoustical Requirements: Seal duct raceway openings on both sides of rooms or walls with acoustically rated putty or firestopping.

D. Interfaces with Other Work:

1. Coordinate with Section 078413 "Penetration Firestopping" for installation of firestopping at penetrations of fire-rated floor and wall assemblies.
2. Coordinate with Section 260529 "Hangers and Supports for Electrical Systems" for installation of conduit hangers and supports.

3.03 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 paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 260533.16
BOXES AND COVERS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Metallic outlet boxes, device boxes, rings, and covers.
   2. Junction boxes and pull boxes.
   3. Cover plates for device boxes.
   4. Hoods for outlet boxes.

B. Products Installed, but Not Furnished, under This Section:
   1. See Section 260553 "Identification for Electrical Systems" for electrical equipment labels.

C. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.02 ACTION SUBMITTALS

A. Product Data:
   1. Metallic outlet boxes, device boxes, rings, and covers.
   2. Junction boxes and pull boxes.
   3. Cover plates for device boxes.
   4. Hoods for outlet boxes.

B. Shop Drawings:
   1. Shop drawings for floor boxes.

PART 2 - PRODUCTS

2.01 METALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria: UL CCN QCIT; including UL 514A.

B. Source Quality Control:
   1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
   2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL QCIT - Metallic Outlet Boxes and Covers:
   1. Description: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides of the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ABB, Electrification Business.
      b. Appleton; Emerson Electric Co., Automation Solutions.
      c. Arlington Industries, Inc.

d. Crouse-Hinds; brand of Eaton, Electrical Sector.
e. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
f. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
g. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
h. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
i. Pass & Seymour; Legrand North America, LLC.
j. Patriot Aluminum Products, LLC.
k. Plasti-Bond; Robroy Industries.
l. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
m. Wiremold; Legrand North America, LLC.

3. Options:
a. Material: Sheet steel.
b. Sheet Metal Depth: Minimum 2 inch.
c. Cast-Metal Depth: Minimum 2.4 inch.
d. Luminaire Outlet Boxes and Covers: Nonadjustable, listed and labeled for attachment of luminaire weighing up to 50 lb.

D. UL QCIT - Metallic Conduit Bodies:
1. Description: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABB, Electrification Business.
b. Appleton; Emerson Electric Co., Automation Solutions.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
f. Pass & Seymour; Legrand North America, LLC.
g. Patriot Aluminum Products, LLC.
h. Plasti-Bond; Robroy Industries.
i. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

E. UL QCIT - Metallic Device Boxes:
1. Description: Box with provisions for mounting wiring device directly to box.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABB, Electrification Business.
b. Appleton; Emerson Electric Co., Automation Solutions.
c. Arlington Industries, Inc.
d. Crouse-Hinds; brand of Eaton, Electrical Sector.
e. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
f. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
g. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

h. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
i. Pass & Seymour; Legrand North America, LLC.
j. Patriot Aluminum Products, LLC.
k. Plasti-Bond; Robroy Industries.
l. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
m. Wiremold; Legrand North America, LLC.

3. Options:
a. Material: Sheet steel.
b. Sheet Metal Depth: minimum 2 inch.
c. Cast-Metal Depth: minimum 2.4 inch.

F. UL QCIT - Metallic Floor Boxes and Floor Box Covers:
1. Description: Box mounted in floor with floor box cover and other components to complete floor box enclosure.
2. Where floor boxes are intended for A/V use, as noted on drawings, provide specific product called out on drawings.
3. For all other floor boxes not intended for A/V use, provide by one of the following manufacturers, subject to compliance with requirements:
a. ABB, Electrification Business.
b. Arlington Industries, Inc.
c. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
d. FSR Inc.
e. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
f. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
g. Leviton Manufacturing Co., Inc.
h. Pass & Seymour; Legrand North America, LLC.
i. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
j. Wiremold; Legrand North America, LLC.

G. UL QCIT - Metallic Concrete Boxes and Covers:
1. Description: Box intended for use in poured concrete.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABB, Electrification Business.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. Wiremold; Legrand North America, LLC.

2.02 RECESSED TV BOXES

A. Provide Chief model PAC526, or equivalent.

2.03 JUNCTION BOXES AND PULL BOXES

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. Listing Criteria: UL CCN BGUZ; including UL 50 and UL 50E.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL BGUZ - Indoor Sheet Metal Junction and Pull Boxes:
1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Appleton; Emerson Electric Co., Automation Solutions.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. FSR Inc.
d. Hoffman; brand of nVent Electrical plc.
e. Hubbell Industrial Controls; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
f. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
g. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
h. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
i. Square D; Schneider Electric USA.
3. Options:
a. Degree of Protection: Type 1 in finished areas Type 12 in high bays, unless otherwise indicated. Type 4X in NDT labs.

D. UL BGUZ - Indoor Cast-Metal Junction and Pull Boxes:
1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Appleton; Emerson Electric Co., Automation Solutions.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
3. Options:
a. Degree of Protection: Type 3R minimum.

E. UL BGUZ - Outdoor Cast-Metal Junction and Pull Boxes:
1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Appleton; Emerson Electric Co., Automation Solutions.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
3. Options:
a. Degree of Protection: Type 3R minimum.

2.04 COVER PLATES FOR DEVICES BOXES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. Listing Criteria: UL CCN QCIT or UL CCN QCMZ; including UL 514D.
3. Wallplate-Securing Screws: Metal with head color to match wallplate finish.

B. Source Quality Control:
1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL QCIT or QCMZ - Metallic Cover Plates for Device Boxes:
1. Options:
a. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
b. Wallplate Material: 0.032 inch thick, Type 302/304 non-magnetic stainless steel with brushed finish.

2.05 HOODS FOR OUTLET BOXES

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. Listing Criteria:
a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
b. Receptacle, Hood, Cover Plate, Gaskets, and Seals: UL 498 Supplement SA when mated with box or enclosure complying with UL 514A, UL 514C, or UL 50E.
3. Mounts to box using fasteners different from wiring device.

B. Source Quality Control:
1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL QCIT or QCMZ - Extra-Duty, While-in-Use Hoods for Outlet Boxes:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ABB, Electrification Business.
b. Allied Tube & Conduit; Atkore International.
c. Appleton; Emerson Electric Co., Automation Solutions.
d. Arlington Industries, Inc.
e. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
f. Intermatic, Inc.
g. Leviton Manufacturing Co., Inc.
h. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
2. Additional Characteristics: Marked "Extra-Duty" in accordance with UL 514D.
3. Options:
a. Provides gray, weatherproof, "while-in-use" cover.
b. Material must be metal. Plastic will not be accepted.

2.06 FLOOR-MOUNTED, RECESSED METAL RACEWAY MULTI-OUTLET ASSEMBLIES

A. Metallic Floor Boxes and Floor Box Covers:

1. Description: Box mounted in floor with floor box cover and other components to complete floor box enclosure.
2. Basis-of-Design Product: Subject to compliance with requirements, provide Hubbell Incorporated; B series or a comparable product by one of the following:
   a. FSR, Inc.
   b. Thomas & Betts Corporation, A Member of the ABB Group.
   c. Wiremold / Legrand.
3. Material: Cast metal or sheet metal.
4. Type: Fully adjustable.
5. Shape: Square.
6. Size: 2 gang.
7. Cover: Metal; finish selected by architect from standard finishes. Provide cover configuration as required to correspond to intended floor finish.
8. Listing and Labeling: Shall comply with UL 514C. Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.07

PART 3 - EXECUTION

3.01 PREPARATION

A. Shop Drawings: Prepare and submit the following:
   1. Shop Drawings for Floor Boxes: Show that floor boxes are located to avoid interferences and are structurally allowable. Indicate floor thicknesswhere boxes are embedded in concrete floors and underfloor clearances where boxes are installed in raised floors.

3.02 SELECTION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NFPA 70 for selection of boxes and enclosures. Consult Architect for resolution of conflicting requirements.

B. Degree of Protection:
   1. Outdoors:
      a. Type 3R unless otherwise indicated.
      b. Locations Exposed to Hosedown: Type 6P.
      c. Locations Subject to Potential Flooding: Type 6P.
   2. Indoors:
      a. Type 1 unless otherwise indicated.
      b. Damp or Dusty Locations: Type 12.
      c. Surface Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
      d. Flush Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
      e. Locations Exposed to Airborne Dust, Lint, Fibers, or Flyings: Type 4.
      f. Locations Exposed to Hosedown: Type 6P. This would include welding and fabrication labs.
      g. Locations Exposed to Brief Submersion: Type 6.
      h. Locations Exposed to Prolonged Submersion: Type 6P. This would include the utility trench in the CNC lab.
      i. Locations Exposed to Corrosive Agents: Type 4X. This would include NDT Labs.
      j. Locations Exposed to Spraying Oil or Coolants: Type 13.

C. Exposed Boxes Installed Less Than 2.5 m (8 ft) Above Floor:
   1. Provide cast-metal boxes.

2. Provide exposed cover. Flat covers with angled mounting slots or knockouts are prohibited.

3.03 INSTALLATION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
   1. Outlet, Device, Pull, and Junction Boxes: Article 314 of NFPA 70.
   2. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:
   1. Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures.
   2. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
   3. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box, whether installed indoors or outdoors.
   4. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
   5. Locate boxes so that cover or plate will not span different building finishes.
   6. Support boxes in recessed ceilings independent of ceiling tiles and ceiling grid.
   7. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for purpose.
   8. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.
   9. Set metal floor boxes level and flush with finished floor surface.
   10. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
   11. Do not install aluminum boxes, enclosures, or fittings in contact with concrete or earth.
   12. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
   13. Boxes and Enclosures in Areas or Walls with Acoustical Requirements:
      a. Seal openings and knockouts in back and sides of boxes and enclosures with acoustically rated putty.
      b. Provide gaskets for wallplates and covers.
   14. Identification: Provide labels for boxes and associated electrical equipment.
      a. Identify field-installed conductors, interconnecting wiring, and components.
      b. Provide warning signs.
      c. Label each box with engraved metal or laminated-plastic nameplate.

D. Interfaces with Other Work:
   1. Coordinate with Section 260573.13 "Short-Circuit Studies" for determining available fault current on input feeder.
   2. Coordinate with Section 260573.19 "Arc-Flash Hazard Analysis" for determining arc-flash hazard on input feeder.

3.04 CLEANING

A. Remove construction dust and debris from boxes before installing wallplates, covers, and hoods.

3.05 PROTECTION

A. After installation, protect boxes from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION

SECTION 260536
CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Metal cable trays.
   2. Cable tray accessories.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

C. Products Installed, but Not Furnished, under This Section:
   1. Section 078413 "Penetration Firestopping" specifies firestopping products installed under this Section.
   2. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding products installed under this Section.
   3. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.

1.02 ACTION SUBMITTALS

A. Product Data:
   1. Metal cable trays.
   2. Cable tray accessories.

B. Shop Drawings:
   1. Cable tray fabrication drawings, diagrams, and supporting documents.

C. Field quality-control reports.

1.03 INFORMATIONAL SUBMITTALS

A. Manufacturers' published instructions.

B. Field Reports:
   1. Factory test reports.
   2. Manufacturer's field reports for field quality-control support.

PART 2 - PRODUCTS

2.01 METAL CABLE TRAYS

A. Description: This product category covers metal cable trays and metal cable tray systems intended for field assembly and for use in accordance with Article 392 of NFPA 70.

B. Performance Criteria:
   1. Regulatory Requirements:
      a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria: UL CCN CYNW; including NEMA VE 1 and suitability for use as equipment grounding conductors in accordance with Sections 392.60(A) and 392.60(B) of NFPA 70.

C. UL CYNW - Wire-Mesh Cable Tray:
   1. Source Limitations: Obtain products from single manufacturer.
   2. General Characteristics:
      a. Configuration: Galvanized-steel wire mesh, complying with NEMA VE 1.

b. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200 lb. concentrated load, when tested in accordance with NEMA VE 1.
c. Splicing Assemblies: Bolted type using serrated flange locknuts.
d. Splice-Plate Capacity: Splices located within support span must not diminish rated loading capacity of cable tray.

3. Materials and Finishes (Steel):
a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A1011/A1011M, SS, Grade 33.
b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
d. Finish:
1) Hot-dip galvanized after fabrication, complying with ASTM A123/A123M, Class B2, with galvanized, ASTM B633 hardware.

4. Options:
a. Width: 24 inch unless otherwise indicated on Drawings.
b. Minimum Usable Load Depth: 2 inch.
c. Straight Section Lengths: 10 ft, except where shorter lengths are required to facilitate tray assembly.

2.02 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
B. Barrier Strips: Same materials and finishes as for cable tray.
C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.03 SOURCE QUALITY CONTROL

A. Product Data: Prepare and submit catalog cuts, brochures, diagrams, and performance data illustrating size, physical appearance, and other characteristics of product.
1. Include data indicating dimensions and finishes for each type of cable tray indicated.
B. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
C. Factory Tests:
1. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
2. Testing Administrant: Engage qualified electrical testing agency to evaluate cable trays.
3. Factory Tests and Inspections: Perform the following tests and inspections on cable trays, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction before delivering to site. Affix label with name and date of qualified electrical testing laboratory's certification of system compliance.
a. Test and inspect cable trays in accordance with NEMA FG 1.
4. Nonconforming Work:
a. Equipment that does not pass tests and inspections will be considered defective.
5. Factory Test Reports: Prepare and submit factory test and inspection reports.

PART 3 - EXECUTION

3.01 PREPARATION

A. Shop Drawings: Prepare and submit the following for each cable tray system:
1. Cable Tray Fabrication Drawings, Diagrams, and Supporting Documents:

a. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
b. Include load calculations to show that dead and live loads do not exceed manufacturer's rating for tray and its support elements.
c. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
    1) Vertical and horizontal offsets and transitions.
    2) Clearances for access above and to sides of cable trays.
    3) Vertical elevation of cable trays above the floor or bottom of ceiling structure.

3.02 INSTALLATION OF CABLE TRAYS

A. Install cable tray and support systems in accordance with NEMA FG 1.
B. Install cable tray as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
C. Install cable tray, so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.
D. Remove burrs and sharp edges from cable trays.
E. Join aluminum cable tray with splice plates; use four square-neck carriage bolts and locknuts.
F. Fasten cable tray supports to building structure and install seismic restraints.
G. Design fasteners and supports to carry cable tray, cables, and a concentrated load of 200 lb. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems." Comply with seismic-restraint details in accordance with Section 260548 "Seismic Controls for Electrical Systems."
H. Place supports, so that spans do not exceed maximum spans on schedules, and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of tray rungs.
I. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
J. Support assembly to prevent twisting from eccentric loading.
K. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.
L. Do not install more than one cable tray splice between supports.
M. Support wire-basket cable trays with trapeze hangers.
N. Support trapeze hangers for wire-basket trays with 3/8 inch diameter rods.
O. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.
P. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed recommended dimensions. Space connectors and set gaps in accordance with applicable standard.
Q. Make changes in direction and elevation using manufacturer's recommended fittings.
R. Make cable tray connections using manufacturer's recommended fittings.
S. Seal penetrations through fire and smoke barriers.

T. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
U. Install cable trays with enough workspace to permit access for installing cables.
V. Install barriers to separate cables of different systems, such as power, communications, and data processing, or of different insulation levels, such as 600, 5000, and 15 000 V.
W. Clamp covers on cable trays installed outdoors with heavy-duty clamps.
X. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.03 CABLE TRAY GROUNDING

A. Ground cable trays in accordance with NFPA 70 unless additional grounding is specified.
B. Cable trays with electrical power conductors must be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
C. Cable trays with single-conductor power conductors must be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72 inch intervals. The grounding conductor must be sized in accordance with Article 250 and Article 392 of NFPA 70.
D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding-bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.
E. Bond cable trays to power source for cables contained within with bonding conductors sized in accordance with Article 250 of NFPA 70.

3.04 INSTALLATION OF CABLES

A. Install cables only when each cable tray run has been completed and inspected.
B. Fasten cables on horizontal runs with cable clamps or cable ties. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
C. Fasten cables on vertical runs to cable trays every 18 inch.
D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure must be no more than 72 inch.
E. Tie mineral-insulated cables down every 36 inch where required to provide a two-hour fire rating and every 72 inch elsewhere.
F. In existing construction, remove inactive or dead cables from cable trays.

3.05 FABRICATION OF CONNECTION POINTS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.
B. Connect raceways to cable trays in accordance with requirements in NEMA VE 2 and NEMA FG 1.

3.06 INSTALLATION OF CABLE TRAY MARKINGS AND SIGNS

A. Trays Containing Cables Operating Over 600 V: Provide hazard markings in accordance with Section 392.18 of NFPA 70 and with NEMA Z535.4.
    1. Legend: "DANGER - HIGH VOLTAGE - KEEP AWAY."

3.07 FIELD QUALITY CONTROL

A. Tests and Inspections:
    1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.

2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items, such as pipes, hangers, or other equipment, in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 Ω.

B. Nonconforming Work:
1. Cable tray will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

END OF SECTION

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SECTION 260543
UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Duct accessories.
   2. Handholes and boxes for exterior underground wiring.
   3. Duct sealing.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" specifies seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
   3. Section 260533.13 "Conduits for Electrical Systems" for PVC, ERMC-S, IMC Conduit and associated fittings and solvents.

1.02 DEFINITIONS

A. Duct: A single raceway or multiple raceways, installed singly or as components of a duct bank.

B. Duct Bank: Two or more ducts installed in parallel, direct buried or with additional casing materials such as concrete.

C. Handhole: An underground chamber containing electrical cables, sized such that personnel are not required to enter in order to access the cables.

D. Manhole: An underground chamber containing electrical cables and equipment, sized to provide access with working space clearances.

E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.03 ACTION SUBMITTALS

A. Product Data:
   1. Duct accessories.
   2. Handholes and boxes for exterior underground wiring.
   3. Duct sealing.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.01 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ABB, Electrification Business.
      b. Allied Tube & Conduit; Atkore International.
      c. Cantex Inc.
      d. IPEX USA LLC.
      e. PenCell Plastics; brand of Hubbell Utility Solutions; Hubbell Incorporated.
      f. Underground Devices, Inc.

B. Underground-Line Warning Tape: In accordance with Section 260553 "Identification for Electrical Systems."

2.02 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover:

1. Description: Molded of sand, concrete, and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or combination.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated.
   b. Oldcastle Infrastructure Inc.; CRH Americas.
   c. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.
3. Configuration: Units must be designed for flush burial and have open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and installed location.
   a. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
   b. Cover Legend: Molded lettering, “FIBER OPTICS”, or “ELECTRIC”, as applicable.
5. Dimensions: Handholes should be provided with size shown on Civil drawings. Where size is not shown, scale from the drawing. Minimum size must be 24” x 24” x 24” minimum for communications use. All others must be 12” x 12” x 12” minimum.
6. Handholes 12 inch wide by 24 inch long and larger must have factory-installed inserts for cable racks and pulling-in irons.
7. Covers must bare an ANSI Tier 15 rating, for occasional non-deliberate traffic.
8. Options:
   a. Color: Gray.

2.03 DUCT SEALING

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

1. ABB, Electrification Business.
2. American Polywater Corporation.
3. CommScope, Inc.
4. Ideal Industries, Inc.
5. NSi Industries LLC.

B. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Compound must be capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals. Duct sealing compound must be removable without damaging ducts or cables.

C. Inflatable Duct-Sealing System: Wraparound inflatable bladder that seals ducts that are empty or containing conductors against air and water infiltration. System is suitable for use in steel, plastic, or concrete ducts and penetrations.

PART 3 - EXECUTION

3.01 PREPARATION

A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in field. Notify Architect if there is conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.

C. Clear and grub vegetation to be removed, and protect vegetation to remain in accordance with Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication in accordance with Section 311000 "Site Clearing."

3.02 SELECTION OF UNDERGROUND DUCTS

A. Duct for Electrical Cables More Than 600 V: PVC-40, concrete encased unless otherwise indicated.

B. Duct for Electrical Feeders 600 V and Less: PVC-40, direct buried unless otherwise indicated.

C. Duct for Electrical Branch Circuits: PVC-40, direct buried unless otherwise indicated.

D. Stub-ups: Concrete encased, ERMC-S or IMC.

3.03 SELECTION OF UNDERGROUND ENCLOSURES

A. Handholes and Boxes:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete, AASHTO HB 17, H-20 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 structural load rating.
3. Units in Sidewalk and Similar Applications with Safety Factor for Nondeliberate Loading by Vehicles: Polymer concrete units, SCTE 77, Tier 8 structural load rating.
4. Cover design load must not exceed load rating of handhole or box.

3.04 EARTHWORK

A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Cut and patch existing pavement in path of underground duct, duct bank, and underground structures in accordance with "Cutting and Patching" Article in Section 017300 "Execution."

3.05 INSTALLATION OF DUCTS AND DUCT BANKS

A. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NEMA TCB 2 for installation of underground ducts and duct banks.
2. Consult Architect for resolution of conflicting requirements.

B. Special Techniques:

1. Where indicated on Drawings, install duct, spacers, and accessories into duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
2. Steel raceway, bends, and fittings in single duct run or duct bank must be of same type.
3. Slope: Pitch duct minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from high point between two manholes to drain in both directions.
4. Install expansion fitting near center of straight line duct with calculated expansion of more than 3/4 inch.
5. Curves and Bends:

a. Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with minimum radius of 48 inch, both horizontally and vertically, at other locations unless otherwise indicated.
b. Field bending must be in accordance with NFPA 70 minimum radii requirements, except bends over 45 degrees must be made with minimum radius of 48 inch. Use only equipment specifically designed for material and size involved. Use PVC heating bender for bending PVC conduit.

6. Joints: Use solvent-cemented joints in nonmetallic duct and fittings and make watertight in accordance with manufacturer's published instructions. Stagger couplings so those of adjacent duct do not lie in same plane. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with minimum 3 inch of concrete for minimum of 12 inch on each side of coupling.
   a. Install insulated grounding bushings on steel raceway terminations that are less than 12 inch below grade or floor level and do not terminate in hubs.
7. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing duct will not be subject to environmental temperatures above 104 deg F. Where environmental temperatures are calculated to rise above 104 deg F, and anywhere duct crosses above underground steam line, install insulation blankets listed for direct burial to isolate duct bank from steam line to maintain maximum environmental temperature of 104 deg F.
8. Building Wall Penetrations: Make transition from underground duct to steel raceway at least 10 ft outside building wall, without reducing duct line slope away from building and without forming trap in line. Use fittings manufactured for transition to steel raceway type installed. Install steel raceway penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
9. Install manufactured steel raceway elbows for stub-ups at poles unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
   a. Couple steel elbows to ducts with adapters designed for this purpose, and encase coupling with minimum 3 inch of concrete for minimum of 12 inch on each side of coupling.
10. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15 psig hydrostatic pressure.
11. Pulling Cord: Install 200 lbf test nylon cord in empty ducts.
12. Concrete-Encased Ducts and Duct Bank:
    a. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes 6 inch or less in nominal diameter.
    b. Width: Excavate trench 12 inch wider than duct on each side.
    c. Depth: Install so top of duct envelope is at least 24 inch below finished grade unless otherwise indicated. Install so top of duct envelope is below local frost line.
    d. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
    e. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 ft of duct. Place spacers within 24 inch of duct ends. Stagger spacers approximately 6 inch between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire

assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.

f. Minimum Space between Ducts: 3 inch between edge of duct and exterior envelope wall, 2 inch between ducts for like services, and 4 inch between power and communications ducts.

g. Elbows:
   1) Use manufactured duct elbows for stub-ups and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
   2) Use manufactured steel elbows for stub-ups, at building entrances, and at changes of direction in duct run.

h. Stub-ups to Outdoor Equipment: Extend concrete-encased steel raceway horizontally minimum of 60 inch from edge of equipment base.
   1) Stub-ups must be minimum 4 inchabove finished floor and minimum 3 inch from conduit side to edge of slab.

i. Stub-ups to Indoor Equipment: Extend concrete-encased steel raceway horizontally minimum of 60 inch from edge of wall. Install insulated grounding bushings on terminations at equipment.
   1) Stub-ups must be minimum 4 inchabove finished floor and no less than 3 inch from conduit side to edge of slab.

j. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.

k. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.

l. Concrete Cover: Install minimum of 3 inch of concrete cover between edge of duct to exterior envelope wall, 2 inch between duct of like services, and 4 inch between power and communications ducts.

m. Place minimum 6 inch of engineered fill above concrete encasement of duct.

n. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
   1) Start at one end and finish at other, allowing for expansion and contraction of duct as its temperature changes during and after pour. Use expansion fittings installed in accordance with manufacturer's published instructions, or use other specific measures to prevent expansion-contraction damage.
   2) If more than one pour is necessary, terminate each pour in vertical plane and install 3/4 inch reinforcing-rod dowels extending minimum of 18 inch into concrete on both sides of joint near corners of envelope.

o. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

13. Direct-Buried Duct and Duct Bank:

a. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inch in nominal diameter.
b. Width: Excavate trench 3 inch wider than duct on each side.
c. Depth: Install top of duct at least 24 inch below finished grade unless otherwise indicated.
d. Set elevation of top of duct bank below frost line.
e. Place minimum 3 inch of sand as bed for duct. Place sand to minimum of 6 inch above top level of duct.
f. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
g. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 ft of duct. Place spacers within 24 inch of duct ends. Stagger spacers approximately 6 inch between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
h. Install duct with minimum of 3 inch between ducts for like services and 6 inch between power and communications duct.
i. Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
j. Install manufactured steel elbows for stub-ups, at building entrances, and at changes of direction in duct.
    1) Stub-ups to Outdoor Equipment: Extend concrete-encased steel raceway horizontally minimum of 60 inch from edge of base. Install insulated grounding bushings on terminations at equipment.
        a) Stub-ups must be minimum 4 inch above finished base and minimum 3 inch from conduit side to edge of base.
    2) Stub-ups to Indoor Equipment: Extend concrete-encased steel raceway horizontally on exterior of wall minimum of 60 inch from edge of wall. Install insulated grounding bushings on terminations at equipment.
    3) Stub-ups through interior floors must be minimum 4 inchabove finished floor and no less than 3 inch from conduit side to edge of equipment pad or floor slab.
k. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inch over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.

14. Underground-Line Warning Tape: Bury nonconducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inch above concrete-encased duct and duct banks and approximately 12 inch below grade. Align tape parallel to and within 3 inch of centerline of duct bank. Provide additional

warning tape for each 12 inch increment of duct-bank width over nominal 18 inch. Space additional tapes 12 inch apart, horizontally across width of ducts.

15. Ground ducts and duct banks in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Interfaces with Other Work:

1. Coordinate installation of new products for chilled water piping and other utility contractors.

3.06 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Special Techniques:

1. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.
2. Unless otherwise indicated, support units on level bed of crushed stone or gravel, graded from 1/2 inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
3. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.
4. Install handholes and boxes with bottom below frost line.
5. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
6. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour concrete ring encircling, and in contact with enclosure entry, and with top surface screeded to top of box cover frame. Bottom of ring must rest on compacted earth.
   a. Concrete: 3000 psi, 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with troweled finish.
   b. Dimensions: 10 inch wide by 12 inch deep.
7. Ground handholes and boxes in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.07 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide minimum 12 inch long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.

B. Nonconforming Work:

1. Underground ducts, raceways, and structures will be considered defective if they do not pass tests and inspections.
2. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.08 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION

SECTION 260544
SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Round sleeves.
   2. Sleeve-seal systems.
   3. Sleeve-seal fittings.
   4. Grout.
   5. Pourable sealants.
   6. Foam sealants.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
   3. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 ROUND SLEEVES

A. Steel Wall Sleeves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Advance Products & Systems, LLC.
      b. CCI Piping Systems.
      c. Flexicraft Industries.
      d. GPT; a division of EnPRO Industries.
      e. Specified Technologies Inc.
   2. General Characteristics: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends and integral waterstop.

B. PVC Pipe Sleeves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CCI Piping Systems.
      b. GPT; a division of EnPRO Industries.
      c. Metraflex Company (The).
   2. General Characteristics: ASTM D1785, Schedule 40.

2.02 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, LLC.
   2. American Polywater Corporation.

3. BWM Company.
4. CALPICO, Inc.
5. Flexicraft Industries.
6. GPT; a division of EnPRO Industries.
7. Proco Products, Inc.

B. General Characteristics: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable or between raceway and cable.

C. Options:
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: Carbon steel.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.03 SLEEVE-SEAL FITTINGS

A. General Characteristics: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit must have plastic or rubber waterstop collar with center opening to match piping OD.

2.04 GROUT

A. General Characteristics: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Design Mix: 5000 psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.05 POURABLE SEALANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carlisle Syntec Systems.
2. GAF.
3. Specified Technologies Inc.

B. Performance Criteria:
1. General Characteristics: Single-component, neutral-curing elastomeric sealants of grade indicated below.
a. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

2.06 FOAM SEALANTS

A. Performance Criteria:
1. General Characteristics: Multicomponent, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam. Foam expansion must not damage cables or crack penetrated structure.

2.07 THROUGH-PENETRATION FLEXIBLE FIRESTOPS

A. Performance Criteria:
1. 3-hour barrier
2. Tested by UL in accordance with ASTM E 814 (UL1479)
3. Tested to UL 910 flammability test.

B. CM Fire Barrier Pillows or equal product.

PART 3 - EXECUTION

3.01 INSTALLATION OF SLEEVES FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Sleeves for Conduits Penetrating Above-Grade, Non-Fire-Rated, Concrete and Masonry-Unit Floors and Walls:
   1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
      a. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall or floor so no voids remain. Tool exposed surfaces smooth; protect material while curing.
      b. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
   2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
   3. Size pipe sleeves to provide 1/4 inch annular clear space between sleeve and raceway or cable, unless sleeve-seal system is to be installed or seismic criteria require different clearance.
   4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
   5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inch above finished floor level. Install sleeves during erection of floors.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Wall Assemblies:
   1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
   2. Seal space outside of sleeves with approved joint compound for wall assemblies.

C. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

D. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve-seal systems. Size sleeves to allow for 1 inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

E. Underground, Exterior-Wall and Floor Penetrations:
   1. Install steel pipe sleeves with integral waterstops. Size sleeves to allow for 1 inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Install sleeve during construction of floor or wall.

3.02 INSTALLATION OF SLEEVE-SEAL SYSTEMS

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install 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.

END OF SECTION

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SECTION 260548
VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Elastomeric isolation pads.
   2. Restraints - rigid type.
   3. Restraints - cable type.
   4. Restraint accessories.
   5. Post-installed concrete anchors.
   6. Concrete inserts.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
   3. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.02 DEFINITIONS

A. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

1.03 ACTION SUBMITTALS

A. Product Data:
   1. Elastomeric isolation pads.
   2. Restraints - rigid type.
   3. Restraints - cable type.
   4. Restraint accessories.
   5. Post-installed concrete anchors.
   6. Concrete inserts.

B. Shop Drawings:
   1. Detail fabrication and assembly of equipment bases.
   2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
   3. Show coordination of seismic and wind-load bracing for components with other systems and equipment in the vicinity, including other supports and seismic restraints.

C. Delegated Design Submittal for Each Seismic-Restraint Device: Signed and sealed by qualified structural professional engineer.
   1. For each seismic-restraint device, including restraint - rigid and cable type, restraint accessory, and concrete anchor and insert that is required by this Section or is indicated on Drawings, submit the following:
      a. Seismic Restraints: Select seismic restraints complying with performance requirements, design criteria, and analysis data.
      b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated seismic loads. Include certification that device is approved by qualified testing laboratory for seismic reinforcement use.

c. Seismic Design Calculations: Submit input data and loading calculations prepared in accordance with criteria specified in Section 260010 "Supplemental Requirements for Electrical" and Section 260011 "Facility Performance Requirements for Electrical."

D. Delegated Design Submittal for Each Wind-Load Protection Device: Signed and sealed by qualified structural professional engineer.

1. For each wind-load protection device, including restraint - rigid and cable type, restraint accessory, and concrete anchor and insert that is required by this Section or is indicated on Drawings, submit the following:

a. Wind-Load Restraint: Select wind-load restraints complying with performance requirements, design criteria, and analysis data.

b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated wind loads. Include certification that device is approved by qualified testing laboratory for reinforcement use.

c. Wind-Load Design Calculations: Submit static and dynamic loading calculations prepared in accordance with criteria specified in Section 260010 "Supplemental Requirements for Electrical" and Section 260011 "Facility Performance Requirements for Electrical."

2. Product Listing, Preapproval, and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

E. Field quality-control reports.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage qualified structural professional engineer to design seismic and wind-load control system in accordance with criteria specified in Section 260010 "Supplemental Requirements for Electrical" and Section 260011 "Facility Performance Requirements for Electrical."

B. Seismic- and Wind-Load-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: an agency acceptable to authorities having jurisdiction.

C. Consequential Damage: Provide additional seismic and wind-load restraints for suspended components or anchorage of floor-, roof-, or wall-mounted components so that failure of a non-essential or essential component will not cause failure of any other essential building component.

D. Fire/Smoke Resistance: Seismic- and wind-load-restraint devices that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by qualified testing laboratory in accordance with ASTM E84 or UL 723, and be so labeled.

E. Component Supports:

1. Load ratings, features, and applications of reinforcement components must be based on testing standards of qualified testing laboratory.

2.02 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

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

a. Ace Mountings Co., Inc.

b. CADDY; brand of nVent Electrical plc.
c. California Dynamics Corporation.
d. Isolation Technology, Inc.
e. Kinetics Noise Control, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Isolation.
h. Vibration Management Corp.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties. Neoprene rubber, silicone rubber, or other elastomeric material.
5. Surface Pattern: Smooth, ribbed, or waffle pattern.

2.03 RESTRAINTS - RIGID TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Atkore Unistrut.
2. CADDY; brand of nVent Electrical plc.
3. California Dynamics Corporation.
4. Cooper B-line; brand of Eaton, Electrical Sector.
5. Hilti, Inc.
6. Isolation Technology, Inc.

B. Description: Shop- or field-fabricated bracing assembly made of ANSI/AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.04 RESTRAINTS - CABLE TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. CADDY; brand of nVent Electrical plc.
2. Cooper B-line; brand of Eaton, Electrical Sector.
3. Gripple Inc.
4. Loos & Co. Inc.

B. Seismic- and Wind-Load-Restraint Cables: ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket, or mechanical (Flemish eye) loop.

C. Restraint cable assembly and cable fittings must comply with ASCE/SEI 19. Cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.05 RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Atkore Unistrut.
2. CADDY; brand of nVent Electrical plc.
3. Cooper B-line; brand of Eaton, Electrical Sector.
4. Hilti, Inc.

5. Loos & Co. Inc.
6. Mason Industries, Inc.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Non-metallic stiffeners are unacceptable.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.06 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Atkore Unistrut.
   b. Cooper B-line; brand of Eaton, Electrical Sector.
   c. Hilti, Inc.
   d. Mason Industries, Inc.
2. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.

B. Adhesive Anchor Bolts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Atkore Unistrut.
   b. Cooper B-line; brand of Eaton, Electrical Sector.
   c. Hilti, Inc.
   d. Mason Industries, Inc.
   e. Powers Fasteners.
2. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

C. Provide post-installed concrete anchors that have been prequalified for use in seismic and wind-load applications.
1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

D. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp that is not vibration isolated.
1. Undercut expansion anchors are permitted.

2.07 CONCRETE INSERTS

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

1. Atkore Unistrut.
2. Cooper B-line; brand of Eaton, Electrical Sector.
3. Hilti, Inc.
4. Mason Industries, Inc.
5. Powers Fasteners.

B. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC446 testing.

C. Comply with MSS SP-58.

2.08 SOURCE QUALITY CONTROL

A. Product Data: Prepare and submit catalog cuts, brochures, diagrams, and performance data illustrating size, physical appearance, and other characteristics of product.

1. Include rated load capacity for each seismic- and wind-load-restraint device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic- and wind-load-restraint component used.
3. Annotate types and sizes of seismic restraints and accessories, complete with listing markings or report numbers and load rating in tension and compression as evaluated by an agency acceptable to authorities having jurisdiction.
4. Annotate to indicate application of each product submitted and compliance with requirements.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and equipment to receive seismic and wind-load control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.02 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry static, wind load, and seismic loads within specified loading limits.

3.03 INSTALLATION OF SEISMIC-RESTRAINT AND WIND-LOAD CONTROL DEVICES

A. Provide seismic restraint and wind-load control devices for systems and equipment where indicated in Equipment Schedules or Seismic and Wind-Load Controls Schedule, where indicated on Drawings, where the Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

1. Install equipment and devices to withstand the effects of earthquake motions and high wind events.

B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

C. Installation of seismic and wind-load restraints must not cause any stresses, misalignment, or change of position of equipment or conduits.

D. Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
2. Install seismic-restraint and wind-load-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

E. Raceway, Cable, Wireway, Cable Tray, and Busway Support and Hanger Restraints:
1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
2. Install seismic-restraint and wind-load-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
3. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
4. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Post-Installed Concrete Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Mechanical-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors must be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.04 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.05 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test no fewer than four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.

B. Nonconforming Work:
1. Seismic controls will be considered defective if they do not pass tests and inspections.
2. Remove and replace malfunctioning units and retest as specified above.

C. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

END OF SECTION

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SECTION 260553
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Labels.
   2. Bands and tubes.
   3. Tapes and stencils.
   4. Tags.
   5. Signs.
   6. Cable ties.
   7. Miscellaneous identification products.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
   3.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

D. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Comply with NFPA 70E and Section 260573.19 "Arc-Flash Hazard Analysis" requirements for arc-flash warning labels.

F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
   1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.02 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:
   1. Black letters on an orange field.
   2. Legend: Indicate voltage.

B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded feeder and branch-circuit conductors.

1. Color shall be factory applied.
2. Colors for 208/120-V Circuits:
   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
3. Colors for 240-V Circuits:
   a. Phase A: Black.
   b. Phase B: Red.
4. Colors for 480/277-V Circuits:
   a. Phase A: Brown.
   b. Phase B: Orange.
   c. Phase C: Yellow.
5. Color for Neutral: White.
6. Color for Equipment Grounds: Green.

C. Raceways and Cables Carrying Circuits at More Than 1000 V:
1. Black letters on orange field.
2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

D. Warning Label Colors:
1. Identify system voltage with black letters on an orange background.

E. Warning labels and signs shall include, but are not limited to, the following legends:
1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

F. Equipment Identification Labels:
1. Black letters on a white field.

2.03 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

B. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Minimum Nominal Size:
   a. 1-1/2 by 6 inches for raceway and conductors.
   b. 3-1/2 by 5 inches for equipment.
   c. As required by authorities having jurisdiction.

2.04 BANDS AND TUBES

A. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

2.05 TAPES AND STENCILS

A. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

B. Underground-Line Warning Tape:
1. Tape:
   a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
   b. Printing on tape shall be permanent and shall not be damaged by burial operations.

c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

2. Color and Printing:
   a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
   b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
   c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

2.06 SIGNS

A. Laminated Acrylic or Melamine Plastic Signs:
   1. Engraved legend.
   2. Thickness:
      a. For signs up to 20 sq. in., minimum 1/16 inch thick.
      b. For signs larger than 20 sq. in., 1/8 inch thick.
      c. Engraved legend with black letters on white face.
      d. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting.
      e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.07 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
   1. Minimum Width: 3/16 inch.
   2. Tensile Strength at 73 Deg F according to ASTM D638: 12,000 psi.
   3. Temperature Range: Minus 40 to plus 185 deg F.
   4. Color: Black, except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
   1. Minimum Width: 3/16 inch.
   2. Tensile Strength at 73 Deg F according to ASTM D638: 12,000 psi.
   3. Temperature Range: Minus 40 to plus 185 deg F.
   4. Color: Black.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
   1. Minimum Width: 3/16 inch.
   2. Tensile Strength at 73 Deg F according to ASTM D638: 7000 psi.
   3. UL 94 Flame Rating: 94V-0.
   4. Temperature Range: Minus 50 to plus 284 deg F.
   5. Color: Black.

2.08 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.01 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.02 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 1000 V: Identification must completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
   1. Secure tight to surface of conductor, cable, or raceway.

H. System Identification for Raceways and Cables over 1000 V: Identification must completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.
   1. Secure tight to surface of conductor, cable, or raceway.

I. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
   1. Secure tight to surface of conductor, cable, or raceway.

J. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

L. Vinyl Wraparound Labels:
   1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
   2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

M. Self-Adhesive Labels:
   1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
   2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.

N. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

O. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

P. Underground Line Warning Tape:
   1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
   2. Limit use of underground-line warning tape to direct-buried cables.
   3. Install underground-line warning tape for direct-buried cables and cables in raceways.

Q. Nonmetallic Preprinted Tags:
   1. Place in a location with high visibility and accessibility.
   2. Secure using general-purpose cable ties.

R. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

S. Cable Ties: General purpose, for attaching tags, except as listed below:
1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.03 LABELLING OF CONTROLLED RECEPTACLES

A. Receptacles that are controlled by occupancy sensors shall be labelled as such.

3.04 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Concealed Raceways, Duct Banks, More Than 1000 V, within Buildings: Tape and stencil. Stencil legend "DANGER - CONCEALED HIGH-VOLTAGE WIRING" with 3 inch high, black letters on 20 inch centers.
1. Locate identification at changes in direction, at penetrations of walls and floors, and at 10 ft maximum intervals.

D. Accessible Raceways, Armored and Metal-Clad Cables, More Than 1000 V: Vinyl wraparound labels.
1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.

E. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.
1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

F. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels to identify the phase.

G. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.

H. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes with the conductor designation.

I. Power-Circuit Conductor Identification, More Than 1000 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and separate tag with circuit designation.

J. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

K. Workspace Indication: In electrical and mechanical rooms, apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

L. Arc Flash Warning Labeling: Self-adhesive labels.

M. Operating Instruction Signs: Self-adhesive labels.

N. Equipment Identification Labels:
1. Indoor Equipment: Laminated acrylic or melamine plastic sign.
2. Outdoor Equipment: Laminated acrylic or melamine sign.

3. Equipment to Be Labeled:
   a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a engraved, laminated acrylic or melamine label.
   b. Enclosures and electrical cabinets.
   c. Access doors and panels for concealed electrical items.
   d. Switchboards.
   e. Switchgear.
   f. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
   g. Enclosed switches.
   h. Enclosed circuit breakers.
   i. Enclosed controllers.
   j. Variable-speed controllers.
   k. Push-button stations.
   l. Contactors.
   m. UPS equipment

END OF SECTION

SECTION 260573.13
SHORT-CIRCUIT AND COORDINATION STUDIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

C. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

D. Section 260573.19 “Arc-Flash Hazard Analysis”

1.02 SUMMARY

A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.03 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed and salvaged, or removed and reinstalled. Existing to remain items shall remain functional throughout the construction period.

B. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.

C. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

D. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.

E. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.

F. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.

G. SCCR: Short-circuit current rating.

H. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

I. Single-Line Diagram: See "One-Line Diagram."

1.04 ACTION SUBMITTALS

A. Product Data:

1. For computer software program to be used for studies.
2. Submit the following after the approval of system protective devices submittals. Submittals may be in digital form.
   a. Short-circuit study input data, including completed computer program input data sheets.
   b. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
      1) Submit study report for approval by engineer prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory. Submit study for

review with associated electrical equipment submittal so that equipment ratings can be verified before finalizing order.

2) Revised one-line diagram, reflecting field investigation results and results of short-circuit study.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. For Power Systems Analysis Software Developer.
   2. For Power System Analysis Specialist.

B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:
   1. For overcurrent protective devices to include in emergency, operation, and maintenance manuals.
   2. The following are from the Short-Circuit Study Report:
      a. Final one-line diagram.
      b. Final Short-Circuit Study Report.
      c. Short-circuit study data files.
      d. Power system data.

1.07 QUALITY ASSURANCE

A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms shall comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.
   1. Power System Analysis Software Qualifications: Computer program shall be designed to perform short-circuit studies or have a function, component, or add-on module designed to perform short-circuit studies.
   2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

D. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

E. Study may be provided by the manufacturer of the gear or an independent contractor such as, but not limited to the following:
   1. ABB
   2. Eaton
   3. Siemens
   4. Square D
   5. William R Jennings, Jr. - Consulting Engineering, PC
      3212 Hill Street
      Unit A
      Lynchburg, VA
      (434) 439-0328

F. Short-Circuit Study Certification: Short-Circuit Study Report shall be signed and sealed by Power Systems Analysis Specialist.

PART 2 - PRODUCTS

2.01 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. EDSA Micro Corporation.
   2. ESA Inc.
   3. Power Analytics, Corporation.
   4. SKM Systems Analysis, Inc.

B. Comply with IEEE 399 and IEEE 551.
   1. Analytical features of power systems analysis software program shall have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.02 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:
   1. Protective device designations and ampere ratings.
   2. Conductor types, sizes, and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
   6. Derating factors and environmental conditions.
   7. Any revisions to electrical equipment required by the study.

D. Comments and recommendations for system improvements or revisions in a written document, separate from one-line diagram.

E. Protective Device Evaluation:
   1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
   2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
   3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
   4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
   5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data:
   1. One-line diagram of system being studied.
   2. Power sources available.
   3. Manufacturer, model, and interrupting rating of protective devices.
   4. Conductors.
   5. Transformer data.

2.03 COORDINATION STUDY REPORT CONTENTS

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kVA and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.
6. Revisions to electrical equipment required by study.
7. Study Input Data: As described in "Power System Data" Article.

    a. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."

D. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in field. Use manufacturer's data sheets for recording recommended setting of overcurrent protective devices when available.

    a. Phase and Ground Relays:

        1) Device tag.
        2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
        3) Recommendations on improved relaying systems, if applicable.

    b. Circuit Breakers:

        1) Adjustable pickups and time delays (long time, short time, and ground).
        2) Adjustable time-current characteristic.
        3) Adjustable instantaneous pickup.
        4) Recommendations on improved trip systems, if applicable.

    c. Fuses: Show current rating, voltage, and class.

E. 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 switching schemes and for emergency periods where power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying portion of system covered.
2. Terminate device characteristic curves at point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
3. Identify 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, as applicable:

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. Largest feeder circuit breaker in each motor-control center and panelboard.

5. Maintain selectivity for tripping currents caused by overloads.

Series rating on equipment allows application of two series interrupting devices for condition where available fault current is greater than interrupting rating of downstream equipment. Both devices share in interruption of fault, and selectivity is sacrificed at high fault levels.

6. Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.
7. Provide adequate time margins between device characteristics such that selective operation is achieved.
8. Comments and recommendations for system improvements.

F.

PART 3 - EXECUTION

3.01 POWER SYSTEM DATA

A. Obtain all data necessary for conduct of the study.
1. Verify completeness of data supplied on one-line diagrams. Call any discrepancies to Engineer's attention.
2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.

3.02 SHORT-CIRCUIT 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 device characteristics supplied by device manufacturer.
D. Extent of electrical power system to be studied includes all switchboards, panelboards, dry-type transformers, relay panels, safety switches, individually-enclosed circuit breakers, and combination starters downstream of the utility service point.
E. Begin short-circuit current analysis at the service, extending down to system overcurrent protective devices as follows:
1. To normal system low-voltage load buses where fault current is 10 kA or less.
F. Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for the fault-current dc decrement to address asymmetrical requirements of interrupting equipment.
G. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
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.
H. Include in the report identification of any protective device applied outside its capacity.

3.03 COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. Base study on device characteristics supplied by device manufacturer.

D. Begin analysis at service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 5 kA or less.

E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

F. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands maximum short-circuit current for time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

G. Generator Protection: Select protection according to manufacturer's instructions and to IEEE 242.

END OF SECTION

SECTION 260573.19
ARC-FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

C. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

D. Section 260573.13 “Short-Circuit Studies”

1.02 SUMMARY

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.03 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.

C. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

D. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.

E. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.

F. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

G. SCCR: Short-circuit current rating.

H. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

I. Single-Line Diagram: See "One-Line Diagram."

1.04 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals may be in digital form:

1. Arc-flash study input data, including completed computer program input data sheets.
2. Arc-flash study report; signed, dated, and sealed by Power Systems Analysis Specialist.
3. Submit study report for approval by engineer prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For Power Systems Analysis Software Developer.
2. For Power System Analysis Specialist.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:
1. Provide maintenance procedures in equipment manuals according to requirements in NFPA 70E.
2. Operation and Maintenance Procedures: In addition to items specified in Section 017823 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.07 QUALITY ASSURANCE

A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms shall comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

D. Power System Analysis Software 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. Computer program shall be designed to perform arc-flash analysis or have a function, component, or add-on module designed to perform arc-flash analysis.
2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

E. Power Systems Analysis Specialist Qualifications: Professional engineer in charge of performing the arc-flash study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer. Specialist shall be the same engineer performing the study required by Section 260573.13 “Short-Circuit Studies”.

F. Arc-Flash Study Certification: Arc-Flash Study Report shall be signed and sealed by Power Systems Analysis Specialist.

PART 2 - PRODUCTS

2.01 COMPUTER SOFTWARE DEVELOPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. EDSA Micro Corporation.
2. ESA Inc.
3. Power Analytics, Corporation.
4. SKM Systems Analysis, Inc.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.02 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
C. One-line diagram, showing the following:
   1. Protective device designations and ampere ratings.
   2. Conductor types, sizes, and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings, including derating factors and environmental conditions.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center, panelboard designations, and ratings.
D. Study Input Data: As described in "Power System Data" Article.
E. Short-Circuit Study Output Data: As specified in Section 260573.13 "Short-Circuit Studies."
F. Protective Device Coordination Study Report Contents: As specified in Section 260573.16 "Coordination Studies."
G. Arc-Flash Study Output Reports:
   1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in the report:
      a. Voltage.
      b. Calculated symmetrical fault-current magnitude and angle.
      c. Fault-point X/R ratio.
      d. No AC Decrement (NACD) ratio.
      e. Equivalent impedance.
      f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
      g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
H. 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. Restricted approach boundary.
   6. Limited approach boundary.
   7. Working distance.
   8. Incident energy.
   9. Hazard risk category.
   10. Recommendations for arc-flash energy reduction.
I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of computer printout.

2.03 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.
B. Label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the relevant information taken directly from the arc-flash hazard analysis.
C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective

devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.02 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies: Perform the Short-Circuit and Protective Device Coordination studies prior to starting the Arc-Flash Hazard Analysis.

C. Calculate maximum and minimum contributions of fault-current size.

D. Calculate the arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except equipment rated 240 V ac or less fed from transformers less than 125 kVA.

F. Calculate the limited, restricted, and prohibited approach boundaries for each location.

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 shall not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators shall be decayed to match the actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash energy shall generally be reported for the maximum of line or load side of a circuit breaker. However, arc-flash computation shall be performed and reported for 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.

3.03 POWER SYSTEM DATA

A. Obtain all data necessary for conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on one-line diagrams on Drawings. Call discrepancies to Engineer's attention.
2. For new equipment, use characteristics from approved submittals under provisions of action submittals and information submittals for this Project.

3.04 LABELING

A. Apply arc-flash label on the front cover of each section of the equipment for each equipment included in the study. Base arc-flash label data on highest values calculated at each location.

B. Each piece of equipment listed below shall have an arc-flash label applied to it:

1. Switchgear
2. Pad-mounted, Oil-filled, Medium-voltage transformers
3. Low-voltage switchboard.
4. Low voltage transformers.
5. Panelboards
6. Safety Switches
7. Individually-enclosed circuit breakers
8. Combination Starters

9. Variable Frequency Controllers

END OF SECTION

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SECTION 260923
LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Outdoor photoelectric switches, solid state, flexible mounting.
   2. Daylight-harvesting dimming controls, digital.
   3. Indoor occupancy and vacancy sensors.
   4. Switchbox-mounted occupancy sensors.
   5. High-bay occupancy sensors.
   6. Lighting contactors.
   7. Conductors and cables.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
   3. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.02 ACTION SUBMITTALS

A. Product Data:
   1. Outdoor photoelectric switches, solid state, flexible mounting.
   2. Daylight-harvesting dimming controls, digital.
   3. Indoor occupancy and vacancy sensors.
   4. Switchbox-mounted occupancy sensors.
   5. High-bay occupancy sensors.
   6. Lighting contactors.

B. Shop Drawings:
   1. Show installation details for the following:
      a. Occupancy sensors.
      b. Vacancy sensors.
   2. Interconnection diagrams showing field-installed wiring.
   3. Include diagrams for power, signal, and control wiring.

C. Field quality-control reports.

1.03 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For manufacturer's warranties.

1.04 WARRANTY

A. Special Extended Warranty: Manufacturer and Installer warrant that installed lighting control devices perform in accordance with specified requirements and agree to repair or replace, including labor, materials, and equipment, devices that fail to perform as specified within extended warranty period.
   1. Failures include, but are not limited to, the following:
      a. Faulty operation of lighting control software.
      b. Faulty operation of lighting control devices.
   2. Extended Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 OUTDOOR PHOTOELECTRIC SWITCHES, SOLID STATE, FLEXIBLE MOUNTING

A. Description: Solid state, with SPST dry contacts rated for 1000 W incandescent or 1800 VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A, and compatible with ballasts and LED lamps.
   1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
   3. Time Delay: Fifteen-second minimum, to prevent false operation.
   4. Surge Protection: Metal-oxide varistor.
   5. Mounting: Twist lock complies with ANSI C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure from same source and manufacturer as switch.
   6. Failure Mode: Luminaire stays ON.

2.02 DAYLIGHT-HARVESTING DIMMING CONTROLS, DIGITAL

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   3. Leviton Manufacturing Co., Inc.
   4. WattStopper; Legrand North America, LLC.
   5. nLight; Acuity Brands Lighting, Inc.

B. Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, lights are dimmed.
   1. Lighting control set point is based on the following two lighting conditions:
      a. When no daylight is present (target level).
      b. When significant daylight is present.
   2. System programming is done with two hand-held, remote-control tools.
      a. Initial setup tool.
      b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.

C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with separate power pack, to detect changes in indoor lighting levels that are perceived by the eye.

D. Electrical Components, Devices, and Accessories:
   1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Sensor Output: zero to 10 V(dc) to operate luminaires. Sensor is powered by controller unit.
   3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc.

E. Power Pack: Digital controller capable of accepting three 8PSJ inputs with one output(s) rated for 20 A incandescent or LED load at 120 and 277 V(ac), for 16 A LED at 120 and 277 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc) Class 2 power source.
   1. With integral current monitoring.
   2. Compatible with digital addressable lighting interface.

3. Plenum rated.

2.03 INDOOR OCCUPANCY AND VACANCY SENSORS

A. General Requirements for Sensors:

1. Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
2. Dual technology.
3. Separate power pack.
4. Hardwired connection to switch; and BAS and lighting control system.
5. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
6. Operation:
   a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
   b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
   c. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A.
8. Power: Line voltage.
9. Power Pack: Dry contacts rated for 20 A LED load at 120 and 277 V(ac), for 13 A tungsten at 120 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
10. Mounting:
    a. Sensor: Suitable for mounting in any position in a standard device box or outlet box.
    b. Relay: Externally mounted through a 1/2 inch knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.
13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

B. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6 inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. inch, and detect a person of average size and weight moving not less than 12 inch in either a horizontal or a vertical manner at an approximate speed of 12 inch/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96 inch high ceiling.

4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 sq. ft. when mounted 48 inch above finished floor.

2.04 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   2. Eaton.
   3. Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   4. Leviton Manufacturing Co., Inc.
   5. Lithonia Lighting; Acuity Brands Lighting, Inc.
   6. Lutron Electronics Co., Inc.
   7. Philips; Signify North America; Signify Holding.
   8. nLight; Acuity Brands Lighting, Inc.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox, with provisions for connection to BAS using hardwired connection.
   1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
   3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
   4. Switch Rating: Not less than 800 VA LED load at 120 V, 1200 VA LED load at 277 V, and 800 W incandescent.

C. Wall-Switch Sensor:
   1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 2100 sq. ft..
   2. Sensing Technology: Dual technology - PIR and ultrasonic.
   3. Switch Type: SP.
   4. Capable of controlling load in three-way application.
   5. Voltage: Match the circuit voltage.
   6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
   7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
   8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
   9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
   10. Color: White.
   11. Faceplate: Color matched to switch.

2.05 HIGH-BAY OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   2. nLight; Acuity Brands Lighting, Inc.

B. Description: Solid-state unit. The unit is designed to operate with the lamp and ballasts indicated.
   1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Operation: Turn lights on when coverage area is occupied, and to half-power when unoccupied; with a time delay for turning lights to half-power that is adjustable over a minimum range of 1 to 16 minutes.
   3. Continuous Lamp Monitoring: When lamps are dimmed continuously for 24 hours, automatically turn lamps on to full power for 15 minutes for every 24 hours of continuous dimming.
   4. Power: Line voltage.
   5. Operating Ambient Conditions: 32 to 149 deg F.
   6. Mounting: Threaded pipe.
   7. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
   8. Detector Technology: PIR.
   9. Power and dimming control from the luminaire ballast that has been modified to include the dimming capacitor.

C. Detector Coverage: User selectable by interchangeable PIR lenses, suitable for mounting heights from 12 to 50 ft..

D. Accessories: Obtain manufacturer's installation and maintenance kit with laser alignment tool for sensor positioning and power port connectors.

2.06 LIGHTING CONTACTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB, Electrification Business.
   2. ASCO Power Technologies.
   3. Allen-Bradley/Rockwell Automation.
   4. Eaton.
   5. Leviton Manufacturing Co., Inc.
   6. Square D; Schneider Electric USA.

B. Description: Electrically operated and mechanically held, combination-type lighting contactors with fusible switch, complying with NEMA ICS 2 and UL 508.
   1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less THD of normal load current).
   2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
   3. Enclosure: Comply with NEMA 250.
   4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.07 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

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

3.02 INSTALLATION OF SENSORS

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's instructions.

3.03 INSTALLATION OF CONTACTORS

A. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.04 INSTALLATION OF WIRING

A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.

B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's instructions.

C. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

3.05 IDENTIFICATION

A. Identify components and power and control wiring in accordance with Section 260553 "Identification for Electrical Systems.

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.06 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Nonconforming Work:

1. Lighting control devices will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Prepare test and inspection reports.

D. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

3.07 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to 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.

END OF SECTION

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SECTION 260936
MODULAR DIMMING CONTROLS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Wall-box multiscene dimming controls.
   2. Multipreset modular dimming controls.
   3. Conductors and cables.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.02 DEFINITIONS

A. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.

B. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.

C. SCR: Silicon-controlled rectifier.

D. Zone: A luminaire or group of luminaires controlled simultaneously as a single entity. Also known as a "channel."

1.03 ACTION SUBMITTALS

A. Product Data:
   1. Wall-box multiscene dimming controls.
   2. Multipreset modular dimming controls.
   3. Conductors and cables.

B. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
   1. Include elevation views of front panels of control and indicating devices and control stations.
   2. Include diagrams for power, signal, and control wiring.
   3. Address Drawing: Reflected ceiling plan and floor plans, showing connected luminaires, address for each luminaire, and luminaire groups. Base plans on construction plans, using the same legend, symbols, and schedules.
   4. Point List and Data Bus Load: Summary list of control devices, sensors, ballasts, and other loads. Include percentage of rated connected load and device addresses.
   5. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with Drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.
   6. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.

C. Samples for Initial Selection: For master- and remote-control stations, and cover plates with factory-applied color finishes and technical features.

D. Samples for Verification: For master- and remote-control stations, and cover plates with factory-applied color finishes and technical features.

E. Field quality-control reports.

1.04 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

1.05 WARRANTY

A. Special Manufacturer Extended Warranty: Manufacturer warrants that components of modular dimming controls perform in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended warranty period.

1. Initial Extended Warranty Period: Two year(s) from date of Substantial Completion, for labor, materials, and equipment.

PART 2 - PRODUCTS

2.01 MODULAR DIMMING CONTROLS

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

1. Douglas Lighting Controls.
2. Leviton Manufacturing Co., Inc.
3. Lutron Electronics Co., Inc.
4. Philips; Signify North America; Signify Holding.

2.02 SYSTEM DESCRIPTION

A. Compatibility:

1. Dimming control components must be compatible with luminaires.
2. Dimming control devices must be compatible with lighting control system components specified in Section 260943.16 "Addressable Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls," and in Section 260923 "Lighting Control Devices."

B. Dimmers and Dimmer Modules: Comply with UL 508.

1. Audible Noise and RFI Suppression: Solid-state dimmers must operate smoothly over their operating ranges without audible lamp or dimmer noise or RFI. Modules must include integral or external filters to suppress audible noise and RFI.
2. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

C. Capacities: Unit must be rated for 2400 W at 240 V(ac) and 2000 W at 120 V(ac) for up to 100 devices or zones.

D. Surge Protection: Withstand supply power surges without impairment to performance.

1. Panels: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.
2. Other System Devices: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.

E. Off Control Position: User-selected off position of any control point must disconnect the load from line supply.

F. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2.03 WALL-BOX MULTISCENE DIMMING CONTROLS

A. Description: Factory-fabricated equipment providing manual dimming consisting of a wall-box-mounted master controller and indicated number of wall-box zone stations. Controls and dimmers must be integrated for mounting in multigang wall box under a single wall

plate. Each zone must be adjustable to indicated number of scenes, which must reside in the memory of zone controller.

B. Dimmers:
   1. Each zone must be configurable to control the following loads:
      a. Fluorescent lamps with electronic ballasts.
      b. LED lamps.
      c. Incandescent lamps.
      d. Control-voltage lamps, derived with magnetic transformers.
      e. Non-dim, on-off switching only.
   2. Regulate voltages to maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent of RMS voltage.

C. Memory:
   1. Retain preset scenes and fade rates through momentary (up to 3 s) power interruptions.
   2. Retain preset scenes through power failures for at least seven days.

D. Device Cover Plates: Style, material, and color must comply with Section 260533.16 "Boxes and Covers for Electrical Systems". Master-control cover plate must be one piece.

E. Master controller must include the following:
   1. Cover-mounted switches, including master off, all bright, and selectors for each scene.
   2. Cover-mounted LED indicator lights, one associated with each scene switch, and one for the master off switch.
   3. Concealed switches and indicators for specified function.
   4. A raise/lower switch for each zone for temporary adjustments of the zone, without altering scene values stored in memory.
   5. Fade time indicated by digital display for current scene while fading.
   6. Cover-mounted infrared receiver.

F. Infrared Transmitters: Wireless remote control for recalling each of the presets. Operate up to 50 ft. within line of sight of the master controller.

2.04 MULTIPRESET MODULAR DIMMING CONTROLS

A. Description: Factory-fabricated equipment providing manual dimming consisting of the following:
   1. Master controller.
   2. Dimmer panels, and indicated number of zone stations.
   3. Controls and dimmers must be integrated for mounting in a multigang wall box under a single wall plate.
   4. Each zone must be adjustable to indicated number of scenes, which must reside in the memory of zone controller.

B. Dimmers:
   1. Regulate voltages to maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent of RMS voltage.

C. Memory: Retain preset scenes and fade settings through power failures by retaining physical settings of controls.

D. Device Cover Plates: Style, material, and color. Master-control cover plate must be one piece.

E. Master controller must include the following:
   1. Wall-box style, single cover plate supplied by manufacturer.
   2. Cover-mounted switches, including master off, all bright, and selectors for each scene.

3. Cover-mounted LED indicator lights, one associated with each scene switch, and one for the master off switch.
4. Concealed switches and indicators for specified function.
5. A raise/lower switch for each zone for temporary adjustments of the zone, without altering scene values stored in memory.
6. Fade time indicated by digital display for current scene while fading.
7. Cover-mounted infrared receiver.

F. Dimmer Panels: Modular, plug-in type, complying with UL 508.
1. Integrated Short-Circuit Rating:, 14 kA at 277 V.
2. Dimmers:
a. Dimming Circuit: Two SCR dimmers, in inverse parallel configuration.
b. Dimming Curve: Modified square law as specified in "The Lighting Handbook" from IES; control voltage is zero to 10 V(dc).
c. Dimming Range: Zero to 100 percent, full output voltage not less than 98 percent of line voltage.
d. Voltage Regulation: Dimmer must maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent of RMS voltage.

G. Circuit Breakers: Complying with UL 489 and classified as switch duty.

2.05 CONDUCTORS AND CABLES

A. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Class 2 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

PART 3 - EXECUTION

3.01 INSTALLATION OF WIRING

A. Wiring Method: Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables" and Section 260533.13 "Conduits for Electrical Systems."

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's instructions.

C. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

3.02 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Label each dimmer module with a unique designation.

C. Label each scene control button with approved scene description.

3.03 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Continuity tests of circuits.
2. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.

a. Include testing of modular dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

B. Nonconforming Work:
1. Dimming control components will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

D. Reports: Prepare written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

E. Manufacturer Services:
1. Engage factory-authorized service representative to support field tests and inspections.

END OF SECTION

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SECTION 260941.13
DIGITAL-NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. System Software Interfaces.
   2. System Backbone and Integration Equipment.
   3. Wired Networked Devices.

B. Related Requirements:
   1. Div. 26: Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
   3. Section 230923 “Direct Digital Control (DDC) System for HVAC” for timeclock and other interfaces.

1.02 DEFINITIONS

A. Data Bus: A wired interface used to communicate with connected devices.

B. Device: A collective term for bus or wireless connected devices, including fluorescent ballasts, LED drivers, incandescent luminaires, manual switches, switching relays, sensors, and similar.

C. Global: Communication between devices in otherwise separate spaces using a bridging device or system controller.

D. Group: A set of devices that communicate together.

E. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

F. Scene: Digital light level associated with a preset.

G. System Backbone: Devices used to connect and manage otherwise separate spaces, including bridging devices and gateways or system controllers. Used to expose devices to software configuration via TCP/IP.

1.03 PREINSTALLATION MEETINGS

A. Preinstallation Coordination Meeting(s): For digital-network lighting controls. Conduct meeting(s) as videoconference or at Project site before commencing work on lighting control systems.
   1. Attendees: Installers, fabricators, representatives of manufacturers, and administrants for field tests and inspections. Notify Construction Manager of scheduled meeting dates.
   2. Engage factory-authorized service representative to attend preinstallation conference and review the submittal drawing, sequence of operation, and device installation best practices with Project team.

1.04 ACTION SUBMITTALS

A. Product Data:
   1. Bill of Materials necessary to install the networked lighting control system.
   2. Product Specification Sheets indicating general device descriptions, dimensions, electrical specifications, wiring details, and nomenclature.
   3. Information Technology (IT) connection information pertaining to interconnection with facility IT networking equipment and third-party systems.

4. Other Diagrams and Operational Descriptions - as needed to indicate system operation or interaction with other system(s).

B. Shop Drawings:
1. Riser Diagrams showing device wiring connections of system backbone and typical per room/area type.

1.05 INFORMATIONAL SUBMITTALS

A. Contractor Startup/Commissioning Worksheet.
B. Service Specification Sheets indicating general service descriptions, including startup, training, post-startup support, and service contract terms.
C. Field quality-control reports.
D. Sample Warranty: For manufacturer's special warranty.

1.06 CLOSEOUT SUBMITTALS

A. Maintenance Contracts:
1. Hardware and Software Operation Manuals
2. Maintenance service agreement.
3. Software service agreement.

B. Warranty documentation.

1.07 QUALITY ASSURANCE

A. Manufacturer Qualifications:
1. Phone Support: Toll-free technical support available from manufacturer through an online tool to schedule a technical support appointment and provide 24/7 emergency support.
2. Remote Support: Manufacturer capable of providing remote support and ability to virtually connect with customers to address issues with visual guidance overlaid on images of real-world objects.
3. Cellular Connectivity: Manufacturer capable of cellular connectivity to a networked lighting control systems available to provide remote support within the continental United States.
4. On-Site Support: Manufacturer capable of providing a 72-hour, on-site response time within the continental United States.
5. Service Contracts: Manufacturer capable of providing service contracts for continued on-site and remote support of the lighting control system post-installation for terms up to 10 years from substantial completion, including:
a. Remote and on-site emergency response.
b. Remote system performance checks.
c. Remote diagnostics.
d. Replacement parts.

1.08 WARRANTY

A. Warranty: Manufacturer and Installer warrant that installed lighting control devices perform in accordance with specified requirements and agree to repair or replace, including labor, materials, and equipment, devices that fail to perform as specified within extended warranty period.
1. Failures include, but are not limited to, the following:
a. Faulty operation of lighting control hardware.
b. Faulty operation of lighting control firmware.
2. Minimum Warranty Period: Five years from date of shipment.

PART 2 - PRODUCTS

2.01 SYSTEM COMPLIANCE

A. System components manufactured in accordance with UL 916 and UL 924 standards where applicable.
B. Performance Criteria:
   1. Regulatory Requirements:
      a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.02 SYSTEM PERFORMANCE REQUIREMENTS

A. System Architecture:
   1. System architecture based upon the following concepts:
      a. Networkable intelligent lighting control devices.
      b. Optional system backbone for remote, time-based, and global operation.
   2. Intelligent lighting control devices with individually addressable network communication capability and having one or more basic lighting control components including: occupancy sensor, photosensor, relay, dimming output, contact closure input, analog 0-10 V(dc) input, and manual wall station capable of indicating switching, dimming, and/or scene control. Combining one or more of these components into a single device enclosure permissible to minimize overall system device count.
   3. System capable of interfacing directly with networked luminaires such that either low-voltage network cabling or wireless RF communication is used to interconnect networked luminaires with control components such as sensors, switches, and system backbone.
   4. Networked luminaires and intelligent lighting control devices support individual (unique) configuration of device settings and properties, with such configuration residing within the networked luminaires and intelligent control devices.
   5. Lighting control zones consisting of one or more networked luminaires and intelligent lighting control devices capable of providing automatic control from sensors (occupancy and/or photosensor) and manual control from local wall stations without requiring connection to a higher-level system backbone.
      a. Lighting control zones (wired and wireless) support at least 128 devices per zone.
      b. Capable of being networked with a higher-level system backbone to provide time-based control, control from inputs or systems external to control zone, and remote configuration and monitoring through a software interface.
   6. Networked luminaires and intelligent lighting control devices with distributed intelligence programming stored in non-volatile memory, such that following any loss of power the lighting control zones operate according to their defined default settings and sequence of operations.
   7. System to include one or more system controllers that provide time-based control.
   8. System controller provides means of connecting the lighting control system to a system software interface and building management systems via BACnet/IP or BACnet MS/TP protocol.
   9. System controller supports both low-voltage wired and wireless RF communication within a single controller device.
   10. System devices support firmware update, either remotely or from within the application space, for purposes of upgrading functionality at a later date.
   11. System capable of reporting lighting system events and performance data to management software for display and analysis.
B. Wired Networked Control Zone Characteristics:

1. Connections to devices within a wired networked lighting control zone and to backbone components accomplished with a single type of low-voltage network cable, compliant with CAT5e specifications or higher. Use of mixed types of low-voltage network cables is unacceptable.
2. Devices connected in "daisy-chain" topology. "Hub-and-spoke" topology, requiring all individual networked devices to be connected to a central component, is unacceptable, to reduce the total amount of network cable required for each control zone.
3. Following proper installation and provision of power, all networked devices connected with low-voltage network cable must automatically form a functional lighting control zone without requiring any type of programming, regardless of the programming mechanism (e.g. software application, handheld remote, pushbutton).
   a. The "out of box" default sequence of operation is intended to provide typical sequence of operation to minimize the system startup and programming requirements and to also have functional lighting control operation prior to system startup and programming.
4. System software capable of automatic discovery of all connected devices without requiring any provisioning of system or zone addresses.
5. Networked devices capable of detecting improper communication wiring and LED notification to alert installation/startup personnel.
6. Networked control devices suitable for control of egress or emergency light sources without additional, externally mounted UL 924 shunting or 0-10 V(dc) disconnect devices, to provide a compliant sequence of operation while reducing the overall installation and wiring costs of the system. Capable of supporting the following sequence of operation:
   a. Low-Voltage Power Sensing: Devices automatically provide 100 percent light level upon detection of loss of power sensed via low-voltage network cable connection where applicable.
   b. Line-Voltage Power Sensing: Devices listed as UL 924 emergency relays which automatically close load-control relay and provide 100 percent light output upon detection of loss of power sensed via line voltage connection to normal power.
7. Global Control Zones: Networked luminaires and intelligent lighting control devices located in different areas able to transmit and track information within at least 128 system-wide control zones to support required sequences of operation that may span multiple areas. Occupancy, photosensor inhibit, and switch commands available across multiple controllers.
8. Wired Networked Wall Station Scene-Control Capabilities:
   a. Preset Scenes that activate a specific combination of light levels across multiple local and global channels.
   b. Local Profile Support: Profile Scenes that modify the sequence of operation for devices in the area (group) in response to a button press to dynamically optimize occupant experience and lighting energy usage.
      1) Wall stations able to manually start and stop local profiles, or local profile capable of ending after a specific duration of time between five minutes and 12 hours.
      2) Configurable Parameters:
         a) Fixture light level.
         b) Occupancy time delay.

c) Response to occupancy sensors (including enabling/disabling response).
d) Response to daylight sensors (including enabling/disabling response).
e) Enabling/disabling wall stations.

c. Three-Way or Multi-Way Control: Multiple wall stations capable of controlling the same local and global control zones, to support "multi-way" preset scene and profile scene control.

C. System Integration Capabilities:
1. Capable of interface with third-party building management systems (BMS) to support two-way communication using BACnet/IP protocol, BACnet MS/TP protocol, and RESTful API including the following system integration capabilities:
a. "Write" messages for control of individual devices, including control of relay and dimming output.
b. "Write" messages for control of groups of devices through a single command, including control of relay and dimming output of all devices.
c. "Read" messages for individual device status information.
1) Available status will vary based on device type and capabilities, which may include relay state, dimming output, power measurement, occupancy sensor status, and photosensor light measurement.
d. "Read" messages for group status information for occupancy, relay state, and dimming output.
e. Activation of pre-defined system Global Profiles.
2. Activation of Global Profiles from third-party systems via dry contact closure output signals or digital commands via RS-232 or RS-485.

D. Supported Sequence of Operations:
1. Control Zones:
a. Local Control Zones: Networked luminaires and intelligent lighting control devices installed in an area (also referred to as a group of devices) capable of transmitting and tracking occupancy sensor, photosensor, and manual switch information within at least 48 unique control zones to support different and reconfigurable sequences of operation within area. These will also be referred to as local control zones.
b. Adjacent Control Zones: Networked luminaires and intelligent lighting control devices capable of tracking occupancy broadcasts from adjacent zones. When this feature is enabled, luminaire output for a vacant zone will reduce to a configurable dimmed state if one or more adjacent zones are occupied. Luminaires will turn off when both primary and adjacent zones are vacant.
c. Global Control Zones: Networked luminaires and intelligent lighting control devices located in different areas able to transmit and track information within at least 128 system-wide control zones to support required sequences of operation that may span across multiple areas. Occupancy, photosensor inhibit, and switch commands available across multiple controllers.
2. Wall Station Capabilities:
a. Wall stations support the following capabilities:
1) On/Off of a local or global control zone.
2) Continuous dimming control of light level of a local or global control zone.
b. Multi-Way Control: Multiple wall stations capable of controlling the same local or global control zones, to support "multi-way" switching and dimming control.

3. Occupancy Sensing Capabilities:
   a. Occupancy sensors configurable to control a local or global zone.
   b. Multiple occupancy sensors capable of controlling the same local or global zones. This capability combines occupancy sensing coverage from multiple sensors without consuming multiple control zones.
   c. Occupancy sensing sequence of operation modes:
      1) On/Off Occupancy Sensing.
      2) Partial-On Occupancy Sensing.
      3) Partial-Off Occupancy Sensing.
      4) Vacancy Sensing (Manual-On / Automatic-Off).
   d. On/Off, Partial-On, and Partial-Off Occupancy Sensing Modes Sequence of Operation:
      1) Occupancy automatically turn lights on to a designated level when occupancy is detected. Designated occupied light level support at least 100 dimming levels.
      2) Occupancy sensors automatically turn lights off or to a dimmed state (Partial-Off) when vacancy occurs or if sufficient daylight is detected. Designated unoccupied dim level support at least 100 dimming levels.
      3) System capable of combining Partial-Off and Full-Off operation by dimming lights to a designated level when vacant and turning the lights off completely after an additional time delay.
      4) Photosensor readings, if enabled in occupancy sensing control zone, automatically adjust light levels during occupied or unoccupied conditions as necessary.
      5) Wall station activation changes the dimming level or turn lights off as selected by the occupant. Lights optionally remain in this manually specified light level until the zone becomes vacant. Upon vacancy, normal sequence of operation resumes.
   e. Vacancy Sensing or Manual-On/Automatic-Off Mode Sequence of Operation:
      1) Activation of a wall station is required turn lights on. System capable of programming the zone to turn on to either a designated light level or previous user-set light level. Initially occupying the space without using a wall station must not result in lights turning on.
      2) Occupancy sensors automatically turn lights off or to a dimmed state (Partial-Off) when vacancy occurs or if sufficient daylight is detected. Designated unoccupied dim level support at least 100 dimming levels.
      3) System capable of dimming the lights when vacant and then turning the lights off completely after an additional time delay.
      4) System capable of an "automatic grace period" immediately following detection of vacancy, during which time any detected occupancy results in the lights reverting to the previous level. After the grace period has expired, the use of a wall station is required to turn lights on.
      5) Photosensor readings, if enabled in the Occupancy Sensing control zone, capable of automatically adjusting the light level during occupied or unoccupied conditions as necessary.
      6) Wall station interaction changes the dimming level or turn lights off as selected by occupant. Lights remain at manually specified light level until zone becomes vacant; normal sequence of operation resumes upon vacancy.

f. Occupancy time delays before dimming or shutting off lights separately programmable for all control zones from 15 seconds to 2 hours.

4. Photosensor Sensing Capabilities (Automatic Daylight Sensing):
   a. Photosensor devices configurable to control a local zone.
   b. Photosensor-Based Control:
      1) Continuous Dimming: Control zone automatically adjusts dimming output in response to photosenor readings, to maintain a minimum light level consisting of both electric light and daylight sources. Photosensor response configurable to adjust set point and dimming rates.
5. Schedule Capabilities:
   a. System capable of time schedules for time-of-day to override devices including offsets from dusk and dawn.
   b. System capable of providing a visible "blink warning" five minutes prior to the end of the schedule.
   c. Wall stations may be programmed to provide timed extensions/overrides that turn the lights on for an additional time period.
      1) Timed override/extension duration programmable for each individual device, zone of devices, or customized group of devices, from five minutes to 12 hours.
6. Global Profile Capabilities:
   a. System capable of automatically modifying the sequence of operation for selected devices in response to any of the following:
      1) Time-of-day schedule.
      2) Contact closure input state.
      3) Manually triggered wired wall station input.
      4) RS-232/RS-485 command to wired input device.
      5) BACnet input command.
   b. Global Profile Capabilities:
      1) Global Profiles stored within and executed from the system controller (via internal timeclock). Dedicated software host or server is not required to be online to support automatic scheduling and/or operation of Global Profiles.
      2) Global Profile time-of-day schedules capable of recurrence settings including daily, specific days of week, every "n" number of days, weekly, monthly, and yearly. Lighting control global profile schedules support definition of start date, end date, end after "n" recurrences, or never ending.
      3) Daylight savings time adjustments capable of being performed automatically, if desired.
      4) Global Profile holiday schedules follow recurrent settings for specific U.S. holiday dates regardless if they always occur on a specific date or are determined by day/week of the month.
      5) Global Profiles capable of being scheduled to run according to timed offsets relative to sunrise or sunset. Sunrise/sunset times automatically derived from location information using an astronomical clock.
      6) Software management interface capable of displaying a graphic calendar view of profile schedules for each control zone.
      7) Global Profiles capable of manual activation directly from system controller, specially programmed wired input devices, scene-capable wired wall stations, and software management interface.

8) Global Profiles selectable to apply to a single device, zone of devices, or customized group of devices.
9) Global Profile Configurable Parameters:
a) Fixture light level.
b) Occupancy time delay.
c) Response to occupancy sensors (including enabling/disabling response).
d) Response to daylight sensors (including enabling/disabling response).
e) Enabling/disabling of wall stations.

c. Local and Global Profiles backed up and stored on software's host server such that Profile backup can be applied to a replacement system controller or wired wall station.

7. System supports automated demand response capabilities with automatic reduction of light level to at least three levels of demand response, configurable for each output device.
8. System must have capability of controlling CCT (correlated color temperature).

2.03 SYSTEMS SOFTWARE INTERFACES

A. Management Interface:
1. Web-based management interface for remote system control, live status monitoring, and configuration of lighting control settings and schedules.
2. Compatible with industry-standard web browser clients.
3. Minimum of 100 unique password-protected user accounts.
4. Minimum of three user permission levels: read-only, read and change settings, and full administrative system access.
5. Capable of restricting access for user accounts to specific devices within the system.
6. All system devices capable of being given user-defined names.
7. Device identification information displayed in the Management interface including:
a. Model number.
b. Model description.
c. Serial number or network ID.
d. Manufacturing date code.
e. Custom label.
f. Parent network device.
8. Management interface capable of displaying live status of a networked luminaire or intelligent control device including:
a. Luminaire on/off status.
b. Dim level.
c. Power consumption.
d. Device temperature.
e. PIR occupancy sensor status.
f. Microphonic occupancy sensor status.
g. Remaining occupancy time delay.
h. Photosensor reading.
i. Active Profiles.
9. Management interface capable of displaying and modifying the current active settings of a networked luminaire or intelligent control device including:
a. Dimming trim levels.
b. Occupancy sensor and photosensor enable/disable.

c. Occupancy sensor time delay and light level settings.
d. Occupancy sensor response (normal or vacancy).
e. Photosensor setpoints and transition time delays.

10. Management interface capable of applying settings changes for a zone of devices or a group of selected devices using a single action that does not require the user to apply settings changes for each individual device.
11. Management interface capable of compiling a printable network inventory report.
12. Management interface capable of compiling a printable report detailing all system profiles.
13. All sensitive information stored encrypted.
14. System software updates available for automatic download and installation via the Internet.

2.04 SYSTEM BACKBONE AND SYSTEM INTEGRATION EQUIPMENT

A. System Controller: Multi-tasking, real-time digital control processor consisting of modular hardware with plug-in enclosed processors, communication controllers, and power supplies.

1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; nECY or comparable product by one of the following:
   a. Cooper Industries, Inc.
   b. Leviton Manufacturing Co., Inc.
   c. Hubbell
2. System Controller Processor: 32-bit microprocessor operating at a minimum of 1 GHz.
3. System Controller Memory: Minimum of 512MB memory, with a minimum of 4GB non-volatile flash, to support operating system and databases.
4. System Controller Functions:
   a. Time-based control of downstream wired and wireless network devices.
   b. Linking into an Ethernet network.
   c. Integration with Building Management Systems (BMS) and Heating, Ventilation and Air Conditioning (HVAC) equipment.
   d. Connection to various software interfaces, including management interface, historical database and analytics interface, and visualization interface.
5. Integral web server to support system controller configuration and diagnostics.
6. Graphical touch screen to support configuration and diagnostics.
7. Minimum of three RJ-45 networked lighting control ports for connection to any of the following:
   a. Graphical touch screen.
   b. Wired communication bridges.
   c. Direct connection to networked wired luminaires and intelligent lighting control devices (up to 128 total devices per port).
8. Device will automatically detect all network-connected devices.
9. Capable of managing and operating a minimum of 750 networked devices (wired or wireless) per system controller.
10. Multiple System Controllers capable of connection via LAN for scalability to a minimum of 20,000 networked devices.
11. Supports BACnet/IP and BACnet MS/TP protocols to directly interface with BMS and HVAC equipment without additional protocol translation gateways.
   a. BACnet MS/TP Connection Speed: 9600 to 115200 baud rate.

b. BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) with outlined enhanced features.

12. Integral FIPS 140-2, Level 1 cryptographic module.
13. Supports RESTful API for control of BACnet objects, user management, date and time, and file management.
14. NEMA 1 enclosure with Class 1 and Class 2 separation.
    a. Power Supply Voltage: 120 to 277 V(ac).
15. Automatic algorithm to eliminate redundant, wireless networked paths to streamline communication between the system controller and end devices.
16. System Controller Security Provisions:
    a. Disallow the use of default passwords and require passwords to be updated prior to use.
    b. Support user role-based access, such as administrator, user, and viewer.
    c. Signed firmware to ensure that unmodified, authentic software is always installed.
    d. IP-based communication protected with strong encryption algorithms such as AES or TLS1.2+.
    e. Prevent rollback of firmware to firmware versions with known, critical vulnerabilities.
    f. Valid cybersecurity listing through a third party.

2.05 WIRED NETWORKED DEVICES

A. Wired Networked Wall Switches, Dimmers, Scene Controllers:
   1. Basis-of-Design Product model numbers are provided on drawings, as based on Acuity nLight controls. Provide as specified or comparable product by one of the following:
      a. Cooper Industries, Inc.
      b. Leviton Manufacturing Co., Inc.
      c. Hubbell
   2. Mounting: Suitable for installation in single-gang switch box.
   3. Communication and low-voltage power delivered via standard low-voltage network cabling with RJ-45 connectors.
   4. All switches detect valid communication and blink a unique LED pattern to visually indicate a potential wiring issue.
   5. Devices with mechanical push buttons provide tactile and LED user feedback.
   6. Devices with mechanical push buttons manufactured with custom button labeling.

B. Networked Graphic Wall Stations:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; nPOD TOUCH or comparable product by one of the following:
      a. Cooper Industries, Inc.
      b. Leviton Manufacturing Co., Inc.
      c. Hubbell
   2. Mounting: Suitable for installation in single-gang switch box.
   3. Integral 3.5-inch capacitive full-color touch screen.
   4. Power via polarity insensitive Class 2 low-voltage 15 to 24V (dc) power supply.
   5. Device enables mobile application control of control zones and scenes through Bluetooth.
   6. Communication over standard low-voltage network cabling with RJ-45 connectors.
   7. User-customizable screen saver utilizing uploaded image file in common file format including jpg, png, gif, bmp, or tif.

8. Capable of configuration of all switches, dimmers, control zones, and lighting preset scenes via password-protected setup screens.
9. Graphic Wall Station Options:
   a. Number of Control Zones: Up to 16.
   b. Number of Scenes: Up to 16.
   c. Profile Scene Duration: User configurable from five minutes to 12 hours.
   d. Color: As selected by Architect.

C. Wired Networked Digital Key Switches:
1. Basis-of-Design Product model numbers are provided on drawings, as based on Acuity nLight controls. Provide as specified or comparable product by one of the following:
   a. Cooper Industries, Inc.
   b. Leviton Manufacturing Co., Inc.
   c. Hubbell.
2. Mounting: Suitable for installation in single-gang switch box.
3. Communication and low-voltage power delivered via standard low-voltage network cabling with RJ-45 connectors.
4. All switches detect valid communication and blink a unique LED pattern to visually indicate a potential wiring issue.
5. LED user feedback to provide indication of on/off status of the programmed lights or scene, as well as indication of device power.
6. Digital Key Switch Options:
   a. Control Types Supported:
      1) On/Off.
   b. Color: Stainless Steel.

D. Wired Networked Occupancy and Photosensors:
1. Basis-of-Design Product model numbers are provided on drawings, as based on Acuity nLight controls. Provide as specified or comparable product by one of the following:
   a. Cooper Industries, Inc.
   b. Leviton Manufacturing Co., Inc.
   c. Hubbell.
2. Detect the presence of human activity within space and fully control the on/off function of lights.
3. Utilize passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state, thus preventing false on conditions. Ultrasonic and Microwave-based sensing technologies are unacceptable.
4. Dual technology sensors used in locations where a second method of sensing is necessary to adequately detect maintained occupancy (such as in rooms with obstructions).
5. Dual technology sensors must have one sensing technology not motion dependent to detect occupancy. Acceptable dual technology includes PIR/Microphonics (also known as Passive Dual Technology or PDT), which detects both occupant motion and sounds indicating occupants. Sensors where both technologies detect motion (PIR/Ultrasonic) are unacceptable.
6. All sensing technologies are acoustically passive, meaning they do not transmit sounds waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space (such as electronic white board readers and hearing devices). Acceptable

detection technologies include Passive Infrared (PIR), and/or Microphonic technology. Ultrasonic and Microwave-based sensing technologies are unacceptable.

7. Ceiling, fixture, recessed, and corner mounted sensors available, with multiple lens options available customized for specific applications.
8. Communication and low-voltage power delivered to each device via standard low-voltage network cabling with RJ-45 connectors.
9. All sensors detect valid communication and blink a unique LED pattern to visually indicate a potential wiring issue.
10. Sensor programming parameter available and configurable remotely from the software and locally via the device push button.
11. Sensors available with one or two occupancy "poles," each of which provides a programmable time delay.
12. Photosensor/daylight override, automatic dimming control, and low temperature/high humidity operation.
13. Photosensor provide one on/off set-point and include a dead band to prevent the artificial light from cycling. Delay incorporated into the photosensor to prevent rapid response to passing clouds.
14. Photosensor and dimming sensor's set-point and dead band automatically calibrated through the sensor's microprocessor by initiating an "Automatic Set-Point Programming" procedure. Min and max dim settings as well as set-point may be manually entered or modified.
15. Dead band setting verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).
16. Dual zone option available for On/Off Photosensor, Automatic Dimming Control Photosensor, or Combination units. The secondary daylight zone capable of being controlled as an "offset" from the primary zone.

E. Wired Networked Wall Switch Sensors:
1. Basis-of-Design Product model numbers are provided on drawings, as based on Acuity nLight controls. Provide as specified or comparable product by one of the following:
   a. Cooper Industries, Inc.
   b. Leviton Manufacturing Co., Inc.
   c. Hubbell.
2. Mounting: Suitable for installation in single-gang switch box.
3. Communication and low-voltage power delivered via standard low-voltage network cabling with RJ-45 connectors.
4. All switches detect valid communication and blink a unique LED pattern to visually indicate a potential wiring issue.
5. Devices with mechanical push buttons provide tactile and LED user feedback.

F. Wired Networked Embedded Fixture Sensors:
1. Basis-of-Design Product model numbers are provided on drawings, as based on Acuity nLight controls. Provide as specified or comparable product by one of the following:
   a. Cooper Industries, Inc.
   b. Leviton Manufacturing Co., Inc.
   c. Hubbell.

2. Network system sensors with occupancy sensors and/or dimming photosensors that can be embedded into luminaire such that only the lens shows on luminaire face.
3. Occupancy sensor detection pattern suitable for 7.5 to 20-ft. mounting heights.

G. Wired Networked Power Packs:
1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; nPP16 series or comparable product by one of the following:
   a. Cooper Industries, Inc.
   b. Leviton Manufacturing Co., Inc.
   c. Hubbell.
2. Plenum rated.
3. Communication will be delivered to each device via standard low-voltage network cabling with RJ-45 connectors.
4. Supply Voltage: 120 to 277 V(ac).
5. Relay Output: Class 1 relay rated for 16 A at 277 V(ac) and 1/2 HP at 120 V(ac).
6. Dimming Output: 0-10 VDC Dimming output.
7. Sink Current: 100 mA at 0-10 V(dc).
8. Mounting: Integral 1/2-inch chase nipple. Plastic clips into junction box are unacceptable.

H. Wired Networked Relay and Dimming Panel:
1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; ARP or comparable product by one of the following:
   a. Cooper Industries, Inc.
   b. Leviton Manufacturing Co., Inc.
   c. Hubbell
2. Outputs: 16 Individual relays per panel, with an equal number of individual 0-10 V(dc) dimming outputs.
3. Field Configurable Relays (FCR):
   a. Field configurable to operate in single-, double-, or triple-pole relay groupings.
   b. Field configurable to operate as normally closed or normally open.
   c. Provides visual status of current state and manual override control of each relay.
   d. Minimum Relay Contact Ratings:
      1) 40 A at 120-480 V(ac) Ballast.
      2) 16 A at 120-277 V(ac) Electronic.
      3) 20 A at 120-277 V(ac) Tungsten.
      4) 20 A at 48V (dc) Resistive.
      5) 2 HP at 120 V(ac).
      6) 3 HP at 240-277 V(ac).
      7) 65kA SCCR at 480 V(ac).
4. Dimming Output Rating: Minimum of 100 mA sink current per dimming output.
5. Relay and dimming outputs individually programmable.
6. Listing: UL 924 for control of emergency lighting circuits.
7. Power Supply: Integrated 120-277 V(ac) supply.
8. Low-Voltage Sensor Input:
   a. Configurable to support any of the following input types:
      1) Indoor Photosensor.
      2) Outdoor Photosensor.
      3) Occupancy Sensor.
      4) Contact Closure.

b. Low-voltage sensor input provides 24 V(dc) power for sensor so additional auxiliary power supplies are not required.
c. Sensor input supports all standard sequence of operations.

9. Contact Closure Input: One for each group of eight output relays that acts as a panel override to activate the normally configured state of all associated relays (i.e., normally open or normally closed).
10. Panel supplies current limited low-voltage power to other networked devices connected via low-voltage network cable.
11. Enclosure:
a. Enclosure Rating: NEMA 1.
b. Mounting: Surface mounted.
c. Cover: Hinged cover with keyed lock.

I. Wired Networked Bluetooth Low-Energy Programming Device:
1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; nIO BT or comparable product by one of the following:
a. Cooper Industries, Inc.
b. Leviton Manufacturing Co., Inc.
c. Hubbell.
2. Plenum rated, inline wired, and screw mountable.
3. Communication and low-voltage power delivered to device via standard low-voltage network cabling with RJ-45 connectors.
4. Bluetooth communication allows connection from smartphone application for programming device settings within the local daisy-chain zone.
5. Device provides visual indication of remote Bluetooth connection via LED integrated into device enclosure such that it is visible from all angles while the zone is being programmed.

J. Wired Networked Communication Bridge:
1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; nBRG or comparable product by one of the following:
a. Cooper Industries, Inc.
b. Leviton Manufacturing Co., Inc.
c. Hubbell
2. Suitable for surface mount to a standard 4 by 4-inch square junction box.
3. Communication Ports: Eight RJ-45 ports for connection to lighting control zones (up to 128 devices per port), additional network bridges, and System Controller.
4. Capable of aggregating communication from multiple lighting control zones for purposes of minimizing backbone wiring requirements back to System Controller.
5. Power Input: Class 2 low-voltage supplied locally via a directly wired power supply.
6. Wired Bridge capable of redistributing power from its local supply and connected lighting control zones with excess power to lighting control zones with insufficient local power. Architecture enables loss of power to a particular area to be less impactful on network lighting control system.

PART 3 - EXECUTION

3.01 INSTALLATION OF WIRING

A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260523 "Control-Voltage Electrical Power Cables." Minimum conduit size is 3/4 inch.

1. Comply with requirements for raceways and boxes specified in Section 260533.13 "Conduits for Electrical Systems," and Section 260533.16 "Boxes and Covers for Electrical Systems,"

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.02 IDENTIFICATION

A. Identify system components, wiring, cabling, boxes, cabinets, and terminals. Comply with identification requirements specified in Section 260553 "Identification for Electrical Systems."

B. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with Section 260553 "Identification for Electrical Systems."

C. Identify all controls with device address.

D. Label each device cable within 6 inch of connection to bus power supply or termination block.

3.03 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Test continuity of each circuit.

B. Tests and Inspections: Engage a factory-authorized service representative to perform test inspections.

1. Test each zone using local and remote control hardware.
2. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.

C. Nonconforming Work:

1. Lighting controls will be considered defective if they do not pass tests and inspections.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Field Test Reports: Prepare field test reports.

1. Prepare functionality and inspection reports, including a certified report that identifies controls included and describes test results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.
2. Include list of all points created from actual tests of all addressed control points for lamps, ballasts, manual controls, and sensors.

3.04 SYSTEM STARTUP

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.
2. Activate luminaires and verify that all maximum output levels match output levels detailed in an Owner-approved sequence of operations.
3. Confirm correct communications wiring, initiate communications between control devices and controller/gateways, and program the lighting control system in accordance with approved configuration schedules, time-of-day schedules, and input override assignments.
4. Program network devices to meet required sequence of operations.
5. Program and verify all sequence of operations.
6. Create backup of system programming.
7. Assist in installation of system software on customer-provided workstation or server.

B. Coordinate timing of startup services with the startup of systems described in Section 230923 “Direct Digital Control (DDC) System for HVAC”.

3.05 CLOSEOUT ACTIVITIES

A. Enhanced Documentation: Engage lighting system manufacturer to provide comprehensive system documentation including detailed programming, sequence of operation data per Project specifications, and related code requirements.

B. Training: Engage lighting system manufacturer to provide comprehensive system overview, software overview, and documentation relating to system operation and maintenance.

3.06 PROTECTION

A. After installation, protect digital network lighting controls from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.07 MAINTENANCE

A. Engage a factory-authorized service representative to perform on-site system adjustments.

1. On-Site Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site settings adjustments to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
2. Prepare and submit report after each visit that details activities performed.

END OF SECTION

SECTION 262416
PANELBOARDS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Power panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Disconnecting and overcurrent protective devices.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" for Surge Protection.

1.02 DEFINITIONS

A. GFEP: Ground-fault equipment protection.

B. MCCB: Molded-case circuit breaker.

C. VPR: Voltage protection rating.

1.03 ACTION SUBMITTALS

A. Product Data:

1. Power panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Disconnecting and overcurrent protective devices.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of listing, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for series rating of installed devices.
7. Include evidence of listing, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for SPD as installed in panelboard.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include wiring diagrams for power, signal, and control wiring.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

1.04 INFORMATIONAL SUBMITTALS

A. Panelboard Schedules: For installation in panelboards.

B. Manufacturers' Published Instructions: Record copy of official installation instructions issued to Installer by manufacturer for the following:

1. Recommended procedures for installing panelboards.
2. Recommended torque settings for bolted connections on panelboards.
3. Recommended temperature range for energizing panelboards.

C. Sample warranties.

1.05 CLOSEOUT SUBMITTALS

A. Warranty documentation.

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Spare Parts: Furnish to Owner spare parts, for repairing panelboards, that are packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:
   1. Keys: Two spares for each type of panelboard cabinet lock.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation in accordance with NEMA PB 1.

1.08 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed panelboards perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
   1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.01 PANELBOARDS COMMON REQUIREMENTS

A. Fabricate and test panelboards in accordance with IEEE 344 to withstand seismic forces defined in Section 260548 "Seismic Controls for Electrical Systems."

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Enclosures dead-front cabinets. Flush- or Surface-mounted, as indicated on drawings
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
   2. Height: 84 inches maximum.
   3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
   4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
   5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
   6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
   7. Finishes:
      a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
      b. Back Boxes: Same finish as panels and trim.

G. Incoming Mains:
   1. Location: Top or Bottom, as applicable.

H. Phase, Neutral, and Ground Buses:
   1. Material: Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity.
      a. Plating shall run entire length of bus.
      b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.

I. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Terminations shall allow use of 75 deg C (or 90 deg C where applicable) rated conductors without derating.
2. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
3. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
4. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
5. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
6. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

J. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

K. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.
3. Contractor to bid based on the AIC ratings based on drawings. Should the short circuit study reduce ratings, a credit shall be provided to owner for the savings.

2.02 PERFORMANCE REQUIREMENTS

A. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1 or Type 2, as indicated on drawings.

B. Metering: Panelboards indicated on drawings shall have metering capabilities. See Section 260913 “Electrical Power Monitoring and Control” for specific requirements.

2.03 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB (Electrification Products Division).
2. Eaton.
3. Schneider Electric USA (Square D).
4. Siemens Industry, Inc., Energy Management Division.

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.04 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB (Electrification Products Division).
2. Eaton.
3. Schneider Electric USA (Square D).
4. Siemens Industry, Inc., Energy Management Division.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only, as indicated on drawings.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.05 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB (Electrification Products Division).
2. Eaton.
3. Schneider Electric USA (Square D).
4. Siemens Industry, Inc., Energy Management Division.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers:
   a. Inverse time-current element for low-level overloads.
   b. Instantaneous magnetic trip element for short circuits.
   c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:
   a. RMS sensing.
   b. Field-replaceable rating plug or electronic trip.
   c. Digital display of settings, trip targets, and indicated metering displays.
   d. Multi-button keypad to access programmable functions and monitored data.
   e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
   f. Integral test jack for connection to portable test set or laptop computer.
   g. Field-Adjustable Settings:
      1) Instantaneous trip.
      2) Long- and short-time pickup levels.
      3) Long and short time adjustments.
      4) Ground-fault pickup level, time delay, and I squared T response.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Subfeed Circuit Breakers: Vertically mounted.
9. MCCB Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.

b. Breaker handle indicates tripped status.
c. UL listed for reverse connection without restrictive line or load ratings.
d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
g. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
h. Shunt Trip: trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
i. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
j. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
k. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

2.06 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
C. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.07 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
B. Receive, inspect, handle, and store panelboards in accordance with NEMA PB 1.1.
C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Comply with manufacturer's published instructions.
B. Reference Standards:
1. Panelboards: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NEMA PB 1.1.
2. Consult Architect for resolution of conflicting requirements.
C. Special Techniques:

1. Equipment Mounting:
   a. Attach panelboard to vertical finished or structural surface behind panelboard.
   b. Mount surface-mounted panelboards to steel slotted supports 5/8 inch in depth. Orient steel slotted supports vertically.
   c. Mount surface-mounted panelboards to steel slotted supports 5/8 inch (16 mm) in depth. Orient steel slotted supports vertically.
   d. Comply with requirements for seismic control devices specified in Section 260548 "Seismic Controls for Electrical Systems."
2. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
3. Mount top of trim 7.5 ft above finished floor unless otherwise indicated.
4. Mount panelboard cabinet plumb and rigid without distortion of box.
5. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
6. Install overcurrent protective devices and controllers not already factory installed.
   a. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver in accordance with manufacturer's published instructions.
7. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
8. Install filler plates in unused spaces.
9. Arrange conductors in gutters into groups and bundle and wrap with wire ties.
10. Mount spare fuse cabinet in accessible location.

D. Interfaces with Other Work:
1. 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, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

3.03 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Panelboard Nameplates: Label each panelboard with nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each branch circuit device in power panelboards with nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

E. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles must be located on interior of panelboard door.

F. Breaker Labels: Faceplate must list current rating, UL and IEC certification standards, and AIC rating.

G. Circuit Directory:
1. Provide computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
   a. Circuit directory must identify specific purpose with detail sufficient to distinguish it from other circuits.

2. Create directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

3.04 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers. Perform optional tests. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:
   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
   b. Instruments and Equipment:
      1) Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

C. Nonconforming Work:

1. Panelboards will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Collect, assemble, and submit test and inspection reports, including certified report that identifies panelboards included and that describes scanning results, with comparisons of two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

3.06 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature in accordance with manufacturer's published instructions.

END OF SECTION

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SECTION 262500
LOW-VOLTAGE ENCLOSED BUS ASSEMBLIES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Enclosed bus assemblies.
   2. Plug-in devices.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.02 ACTION SUBMITTALS

A. Shop Drawings: For each type of product.
   1. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.
   2. Show fittings, materials, fabrication, and installation methods for.
   3. Indicate required clearances, method of field assembly, and location and size of each field connection.
   4. Detail connections to switchgear, switchboards, transformers, and panelboards.
   5. Cable and conductor terminal sizes for bus and plug-in device terminations.
   6. Wiring Diagrams: Power wiring.

B. Delegated Design Submittal: For seismic-restraint details, signed and sealed by a qualified structural professional engineer.
   1. Include design calculations for selecting seismic restraints.
   2. Detail fabrication, including anchorages and attachments to structure and to supported equipment.

1.03 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.04 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. Plug-in Units: 10 percent of amount installed for each size indicated, but no fewer than 2 unit(s).

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle enclosed bus assemblies according to NEMA BU 1.1, "General Instructions for Handling, Installation, Operation, and Maintenance of Busway Rated 600 Volts or Less."

PART 2 - PRODUCTS

2.01 ASSEMBLY DESCRIPTIONS

A. Source Limitations: Obtain enclosed bus assemblies and plug-in devices from single source from single manufacturer.

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. Comply with UL 857.

2.02 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified electrical professional engineer to design enclosed bus assemblies, plug-in devices, and components.

2.03 ENCLOSED BUS ASSEMBLIES

A. Feeder-Bus Assemblies: Low-impedance bus assemblies in totally enclosed, nonventilated housing; single-bolt joints; ratings as indicated.
   1. Provide Starline, by Legrand, or equal product.
   2. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for feeder-bus assemblies with reinforcement strong enough to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems" when mounting provisions and attachments are anchored to building structure.
   3. Electrical Characteristics:
      a. Voltage: 120/208 V.
      b. Phase: Three; 4 wire.
      c. Percent of Neutral Capacity: 100.
   4. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
   5. Bus Materials: Current-carrying copper conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.
   6. Voltage Drop:
      a. Measure voltage drop at 30 deg C ambient with bus thermally stabilized at full rated load.
      b. Three-phase, line-to-line voltage drop less than 3.1 V per 100 ft. at 40 percent power factor.
   7. Enclosure: Steel, with manufacturer's standard finish.
   8. Fittings and Accessories: Manufacturer's standard.
   9. Mounting: Arranged flat, edgewise, or vertically without derating. Rated for hanger spacing of up to 10 ft. for horizontally mounted runs and up to 16 ft. for vertically mounted runs.
   10. Expansion Section: Manufacturer's standard expansion fitting for the provided busway with expansion capability to accommodate thermal expansion of bus and enclosure, and to accommodate movement across building expansion joints.

B. Plug-in Bus Assemblies: Low-impedance bus assemblies in totally enclosed, nonventilated housing; single-bolt joints; ratings as indicated.
   1. Electrical Characteristics:
      a. Voltage: 120/208 V.
      b. Phase: Three; 4 wire.
   2. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
   3. Bus Materials: Current-carrying copper conductors, fully insulated with Class 130C insulation except at stabs and joints; plated surface at stabs and joints.
   4. Enclosure: Steel, with manufacturer's standard finish.
   5. Plug-in Openings: 24 inch on center on each side of bus, and hinged covers over unused openings. Plug-in openings must be finger-safe with covers open or closed.
   6. Fittings and Accessories: Manufacturer's standard.
   7. Firestop: Comply with UL 1479 firestop system, listed and labeled by an NRTL acceptable to authorities having jurisdiction for penetrations of fire-rated walls, ceilings, and floors.

8. Mounting: Arranged flat, edgewise, or vertically without derating. Rated for hanger spacing of up to 10 ft. for horizontally mounted runs and up to 16 ft. for vertically mounted runs.
9. Expansion Section: Manufacturer's standard expansion fitting for the provided busway with expansion capability to accommodate thermal expansion of bus and enclosure, and to accommodate movement across building expansion joints.

C. Joints:
1. Busway joints must use one high-strength steel bolt with Belleville washers.
2. Bolts must be torque indicating type and at ground potential.
3. Bolts must be two-headed design to indicate when proper torque has been applied and require only a standard long handle wrench to be properly activated.
4. Access must be required to only one side of the busway for tightening joint bolts.
5. Joint connection assemblies must be removable without disturbing adjacent busway lengths.
6. Joint connection assemblies that rely on the joint cover to provide ground continuity are unacceptable.

2.04 PLUG-IN DEVICES

A. Fusible Switches: NEMA KS 1, heavy duty; with R-type rejection fuse clips to accommodate specified fuses; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. Interlocked to prevent plug-in device insertion into or removal from bus with switch in closed position. See Section 262813 "Fuses" for fuses and fuse installation requirements.

B. Molded-Case Circuit Breakers: UL 489; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. Interlocked to prevent plug-in device insertion into or removal from bus with switch in closed position.

C. SPD: NEMA 250, Type 1 enclosure with NEMA KS 1, fusible, disconnect switch and external handle to isolate SPD from busway. SPD product and installation requirements are specified in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."

PART 3 - EXECUTION

3.01 INSTALLATION

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 luminaires, HVAC equipment, fire-suppression system, and partition assemblies.

B. Equipment Mounting:
1. Install enclosed bus assemblies on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Coordinate size and location of concrete curbs around openings for vertical bus. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Support bus 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 load indicated by seismic requirements and to comply with seismic-restraint details according to Section 260548.16 "Seismic Controls for Electrical Systems."
2. Design each fastener and support to carry 200 lb or 4 times the weight of bus assembly, whichever is greater.
3. Support bus assembly to prevent twisting from eccentric loading.

4. Support bus assembly with not less than 3/8 inch 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.
5. Fasten supports securely to building structure according to Section 260529 "Hangers and Supports for Electrical Systems."
6. Bolts and nuts that are loosened for any reason after tightening to manufacturer's recommended torque setting must be discarded and replaced with new bolts and nuts.

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 Section 078413 "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 Section 079200 "Joint Sealants" for materials and application.

G. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.

H. 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.

I. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

3.02 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. After installing equipment, test for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with Drawings and Specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, and grounding.
   d. Verify correct connection according to single-line diagram.
   e. Inspect bolted electrical connections for high resistance using one or more of the following methods:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
      3) Perform thermographic survey.
3. Electrical Tests:
   a. Perform insulation resistance measurements through bolted connections and bus joints with low-resistance ohmmeter.
   b. Perform insulation resistance tests of each busway, phase to phase, and phase to ground.

c. Perform a dielectric withstand voltage test on each busway, phase to ground with phases not under test grounded for one minute.
d. Measure resistance of assembled busway sections on insulated busway and compare values with adjacent phases.
e. Perform phasing test on each busway tie section energized by separate sources.
f. Verify operation of busway space heaters.

B. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

C. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

D. Nonconforming Work:
1. Enclosed bus assemblies will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.04 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.05 PROTECTION

A. Provide final protection to ensure that moisture does not enter bus assembly.

END OF SECTION

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SECTION 262726
WIRING DEVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.02 SUMMARY

A. Section Includes:

1. Standard-grade receptacles, 125 V, 20 A.
2. GFCI receptacles, 125 V, 20 A.
3. Twist-locking receptacles.
4. Isolated Ground receptacles.
5. Wall plates.

1.03 DEFINITIONS

A. AFCI: Arc-fault circuit interrupter.

B. Commercial/Industrial-Use Cord Reel: A cord reel subject to severe use in factories, commercial garages, construction sites, and similar locations requiring a harder service-type cord.

C. BAS: Building automation system.

D. EMI: Electromagnetic interference.

E. GFCI: Ground-fault circuit interrupter.

F. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

G. RFI: Radio-frequency interference.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.05 WARRANTY FOR CORD REELS

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed cord-reel power outlet assemblies perform in accordance with specified requirements and agrees to repair or replace assemblies that fail to perform as specified within extended warranty period.

1. Extended Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.

B.

PART 2 - PRODUCTS

2.01 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Comply with NFPA 70.

C. RoHS compliant.

D. Comply with NEMA WD 1.

E. Receptacle devices noted as controlled on the drawings shall specifically be designed to be controlled by occupancy sensors systems. Provide all necessary components for a fully-operational system.

F. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
   1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
   2. Devices shall comply with requirements in this Section.
G. Devices for Owner-Furnished Equipment:
   1. Receptacles: Match plug configurations.
H. Device Color:
   1. Wiring Devices Connected to Normal Power System: White unless otherwise indicated or required by NFPA 70 or device listing.
   2. Wiring Devices connected to Generator Power System: Red unless otherwise indicated or required by NFPA 70 or device listing.
   3. Wiring Devices connected to UPS Power System: Orange unless otherwise indicated or required by NFPA 70 or device listing.
I. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.02 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

A. Duplex Receptacles, 125 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton (Wiring Devices - Arrow Hart).
      b. Hubbell Incorporated (Wiring Device-Kellems).
      c. Legrand North America, LLC (Pass & Seymour).
      d. Leviton Manufacturing Co., Inc.
   2. Description: Two pole, three wire, and self-grounding.
   3. Configuration: NEMA WD 6, Configuration 5-20R.
   4. Standards: Comply with UL 498 and FS W-C-596.
   5. Color: Red for generator circuits, all others color selected by architect.
B. Isolated-Ground Duplex Receptacles, 125 V, 20 A:
   1. Acceptable manufacturers as listed in Duplex receptacles section.
   2. Description: Straight blade; equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts. Two pole, three wire, and self-grounding.
   3. Configuration: NEMA WD 6, Configuration 5-20R.
   4. Standards: Comply with UL 498 and FS W-C-596.
   5. Color: Red for generator circuits, all others color selected by architect.
C. Night Light Duplex Receptacles, 125 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton (Wiring Devices - Arrow Hart).
      b. Hubbell Incorporated (Wiring Device-Kellems).
      c. Legrand North America, LLC (Pass & Seymour).
      d. Leviton Manufacturing Co., Inc.
   2. Description: Two pole, three wire, and self-grounding with LED night lights.
   3. Configuration: NEMA WD 6, Configuration 5-20R.
   4. Standards: Comply with UL 498 and FS W-C-596.
   5. Color: Red for generator circuits, all others color selected by architect.
   6. Functionality: Include a photocell to turn on night light only when space is dark.

2.03 GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A:
   1. Acceptable manufacturers as listed in Duplex receptacles section.
   2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
   3. Configuration: NEMA WD 6, Configuration 5-20R.
   4. Type: Non-feed through.
   5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
   6. Color: Red for generator circuits, all others color selected by architect.

B. Tamper- and Weather-Resistant, GFCI Duplex Receptacles, 125 V, 20 A:
   1. Acceptable manufacturers as listed in Duplex receptacles section.
   2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
   3. Configuration: NEMA WD 6, Configuration 5-20R.
   4. Type: Non-feed through.
   5. Standards: Comply with UL 498 and UL 943 Class A.
   6. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.04 TWIST-LOCKING RECEPTACLES

A. Twist-Lock, Single Receptacles, 125 V, 30 A:
   1. Acceptable manufacturers as listed in Duplex receptacles section.
   2. Configuration: NEMA WD 6, Configuration L5-30R.
   3. Standards: Comply with UL 498.

B. Twist-Lock, Single Receptacles, 250 V, 30 A:
   1. Acceptable manufacturers as listed in Duplex receptacles section.
   2. Configuration: NEMA WD 6, Configuration L6-30R.
   3. Standards: Comply with UL 498.

2.05 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.
   1. Plate-Securing Screws: Metal with head color to match plate finish.
   2. Material for Finished Spaces: 0.035-inch-thick, satin-finished, Type 302 stainless steel.
   3. Material for Unfinished Spaces: Galvanized steel.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.06 SPECIAL-PURPOSE POWER OUTLET ASSEMBLIES

A. Spring-Driven Commercial/Industrial-Use Cord Reel, No. 12 AWG Conductors:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. General Characteristics:

      a. Reference Standards: UL CCN SBCV and UL 355.
      b. Spring take-up retraction mechanism.

3. Options:

a. Electrical Rating with Cable: 600 V, 20 A.
b. Color: Yellow.
c. Enclosure Degree of Protection: Type 4X.
d. Ball stop.
e. Pivot base.
f. Spool Capacity:

1) No. 12 AWG, two wires and equipment ground, 40 ft (12.2 m).

PART 3 - EXECUTION

3.01 EXAMINATION

A. Receptacles:

1. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

B. Cord Reels:

1. Examine roughing-in for cord reel mounting and power connections to verify actual locations of mounts and power connections before cord reel installation.
2. Examine walls, floors, and ceilings for suitable conditions where cord reel will be installed.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 ISOLATED GROUND RECEPTACLE APPLICATION:

A. Use isolated ground receptacles in all IT rooms and for all circuits fed from the following panels:
1. AV1
2. AV2

3.03 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:
1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:
1. Do not strip insulation from conductors until right 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 comply with NFPA 70, Article 300, without pigtails.

4. 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.

D. Device Installation:
   1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
   2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
   4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
   5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
   6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
   7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
   8. Tighten unused terminal screws on the device.
   9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
   1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.04 GFCI RECEPTACLES

A. Install non-feed-through GFCI receptacles. Even where multiple devices are required on a single circuit, install GFCI receptacles at each location.

3.05 INSTALLATION OF CORD REELS AND FITTINGS

A. Comply with manufacturer's instructions.

3.06 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

3.07 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Perform the following tests and inspections:
   1. Test Instruments: Use instruments that comply with UL 1436.
   2. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

D. Tests for Receptacles:
   1. Line Voltage: Acceptable range is 105 to 132 V.
   2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
   3. Ground Impedance: Values of up to 2 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. 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.

E. Wiring device will be considered defective if it does not pass tests and inspections.

END OF SECTION

SECTION 262813
FUSES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Cartridge fuses rated 600 V ac and less for use in the following:
      a. Control circuits.
      b. Enclosed controllers.
      c. Enclosed switches.
   2. Spare-fuse cabinets.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
   1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
      a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
      b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
   2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
   3. Current-limitation curves for fuses with current-limiting characteristics.
   4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in PDF format.
   5. Coordination charts and tables and related data.
   6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017700 "Closeout Procedures," include the following:
   1. Ambient temperature adjustment information.
   2. Current-limitation curves for fuses with current-limiting characteristics.
   3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in PDF format.
   4. Coordination charts and tables and related data.

1.05 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: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.06 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. ABB.
2. Eaton (Bussmann & Edison).
3. Littelfuse, Inc.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.02 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
   1. Type RK-5: 600-V, zero- to 600-A rating, 200 kAIC.
   2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC.
   3. Type J: 600-V, zero- to 600-A rating, 200 kAIC.
   4. Type L: 600-V, 601- to 6000-A rating, 200 kAIC.

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. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.03 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
   1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
   2. Finish: Gray, baked enamel.
   3. Identification: "SPARE FUSES" in 1-1/2-inch-high letters on exterior of door.
   4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.02 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Motor Branch Circuits: Class RK5, time delay.
2. Large Motor Branch (601-4000 A): Class L, time delay.
3. Power Electronics Circuits: Class J, high speed.
4. Other Branch Circuits: Class J, time delay.
5. Control Transformer Circuits: Class CC, time delay, control transformer duty.
6. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.03 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Construction Manager.

3.04 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

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SECTION 262816
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Fusible switches.
   2. Nonfusible switches.
   3. Molded-case circuit breakers (MCCBs).
   4. Enclosures.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.02 DEFINITIONS

A. GFEP: Ground-fault circuit-interrupter for equipment protection.

B. GFLS: Ground-fault circuit-interrupter for life safety.

C. SPDT: Single pole, double throw.

1.03 ACTION SUBMITTALS

A. Product Data:
   1. For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
   2. Enclosure types and details for types other than UL 50E, Type 1.
   3. Current and voltage ratings.
   4. Short-circuit current ratings (interrupting and withstand, as appropriate).
   5. Include evidence of qualified electrical testing laboratory listing for series rating of installed devices.
   6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
   7. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.

B. Shop Drawings: For enclosed switches and circuit breakers.
   1. Include plans, elevations, sections, details, and attachments to other work.
   2. Include wiring diagrams for power, signal, and control wiring.

C. Field Quality-Control Submittals:
   1. Field quality-control reports.

1.04 INFORMATIONAL SUBMITTALS

A. Sample warranties.

1.05 CLOSEOUT SUBMITTALS

A. Warranty documentation.

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Spare Parts: Furnish to Owner spare parts, for repairing enclosed switches and circuit breakers, that are packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:

1. Fuses: as required by Section 262813 “Fuses”
2. Fuse Pullers: as required by Section 262813 “Fuses”

1.07 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed enclosed switches and circuit breakers perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
   1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Source Limitations: Obtain products from single manufacturer.
B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
C. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.02 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB, Electrification Business.
   2. Eaton.
   3. Siemens Industry, Inc., Energy Management Division.
   4. Square D; Schneider Electric USA.
B. Type HD, Heavy Duty:
   1. Single throw.
   2. Three pole.
   3. 240 or 600 V(ac), as applicable.
   4. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
   5. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
C. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
   3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
   4. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.03 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB, Electrification Business.
   2. Eaton.
   3. Siemens Industry, Inc., Energy Management Division.
   4. Square D; Schneider Electric USA.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 240 or 600 V(ac), as applicable, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
   3. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.04 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB, Electrification Business.
   2. Eaton.
   3. Siemens Industry, Inc., Energy Management Division.
   4. Square D; Schneider Electric USA.

B. Circuit breakers must be constructed using glass-reinforced insulating material. Current carrying components must be completely isolated from handle and accessory mounting area.

C. Circuit breakers must have toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. Circuit-breaker handle must be over center, be trip free, and reside in tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon must be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with push-to-trip button, located on face of circuit breaker to mechanically operate circuit-breaker tripping mechanism for maintenance and testing purposes.

D. Maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings must be clearly marked on face of circuit breaker. Circuit breakers must be 100 percent rated

E. MCCBs must be equipped with device for locking in isolated position.

F. Lugs must be suitable for 75 deg C rated wire.

G. Standard: Comply with UL 489 with required interrupting capacity for available fault currents.

H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

J. Electronic Trip Circuit Breakers: Field-replaceable rating plug, RMS sensing, with the following field-adjustable settings:
   1. Instantaneous trip.
   2. Long- and short-time pickup levels.
   3. Long- and short-time time adjustments.
   4. Ground-fault pickup level, time delay, and I-squared t response.

K. Features and Accessories:
   1. Standard frame sizes, trip ratings, and number of poles.
   2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.

2.05 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, UL 50E, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: Enclosure must be gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (UL 50E Type 1) gray baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel (UL 50E Types 3R, 12) a brush finish on Type 304 stainless steel (UL 50E Type 4-4X stainless steel).

C. Conduit Entry: UL 50E Types 4, 4X, and 12 enclosures may not contain knockouts. UL 50E Types 7 and 9 enclosures must be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: Circuit-breaker operating handle must be externally operable with operating mechanism being integral part of box, not cover. Cover interlock mechanism must have externally operated override. Override may not permanently disable interlock mechanism, which must return to locked position once override is released. Tool used to override cover interlock mechanism must not be required to enter enclosure in order to override interlock.

E. Enclosures designated as UL 50E Type 4, 4X stainless steel, 12, or 12K must have dual cover interlock mechanism to prevent unintentional opening of enclosure cover when circuit breaker is ON and to prevent turning circuit breaker ON when enclosure cover is open.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

1. Commencement of work will indicate Installer's acceptance of areas and conditions as satisfactory.

3.02 SELECTION OF ENCLOSURES

A. Indoor, Dry and Clean Locations: UL 50E, Type 1, unless specifically indicated otherwise..

B. Outdoor Locations: UL 50E, Type 3R.

C. Wash-Down Areas: UL 50E, Type 4X, stainless steel. This would include the Welding, Fabrication, and NDT #2 labs.

D. Other Wet or Damp, Indoor Locations: UL 50E, Type 4.

E. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: UL 50E, Type 12.

3.03 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Special Techniques:

1. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
2. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
3. Comply with mounting and anchoring requirements specified in Section 260548 "Seismic Controls for Electrical Systems."
4. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
5. Install fuses in fusible devices.

3.04 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.05 FIELD QUALITY CONTROL

A. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:
   a. Inspect physical and mechanical condition.
   b. Inspect anchorage, alignment, grounding, and clearances.
   c. Verify that unit is clean.
   d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
   e. Verify that fuse sizes and types match the Specifications and Drawings.
   f. Verify that each fuse has adequate mechanical support and contact integrity.
   g. Inspect bolted electrical connections for high resistance using one of the following methods:
      1) Use low-resistance ohmmeter.
         a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
         a) Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS Table 100.12.
   h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on Drawings.
   i. Verify correct phase barrier installation.
   j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.
2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
   b. Measure contact resistance across each switchblade fuseholder. Drop values may not exceed high level of manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
   c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, use Table 100.1 from NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
   d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
   e. Perform ground fault test in accordance with NETA ATS Section 7.14 "Ground Fault Protection Systems, Low-Voltage."

B. Tests and Inspections for Molded-Case Circuit Breakers:
   1. Visual and Mechanical Inspection:
      a. Verify that equipment nameplate data are as described in the Specifications and shown on Drawings.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding, and clearances.
      d. Verify that unit is clean.
      e. Operate circuit breaker to ensure smooth operation.
      f. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use low-resistance ohmmeter.
            a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
            a) Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS Table 100.12.
      g. Inspect operating mechanism, contacts, and chutes in unsealed units.
      h. Perform adjustments for final protective device settings in accordance with coordination study.
   2. Electrical Tests:
      a. Perform resistance measurements through bolted connections with low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
      b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, use Table 100.1 from NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
      c. Perform contact/pole resistance test. Drop values may not exceed high level of manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
      d. Perform insulation resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values may be no less than 2 M Ω.
      e. Determine the following by primary current injection:
         1) Long-time pickup and delay. Pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

2) Short-time pickup and delay. Short-time pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
3) Ground-fault pickup and time delay. Ground-fault pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
4) Instantaneous pickup. Instantaneous pickup values must be as specified and within manufacturer's published tolerances.

f. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of shunt trip and close coils must be as indicated by manufacturer.
g. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset trip logs and indicators. Investigate units that do not function as designed.
h. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Test and adjust controls, remote monitoring, and safeties.

C. Nonconforming Work:
1. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Collect, assemble, and submit test and inspection reports.
1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.06 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

3.07 PROTECTION

A. After installation, protect enclosed switches and circuit breakers from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.08 MAINTENANCE

A. Infrared Scanning of Enclosed Switches and Breakers: Two months after Substantial Completion, perform infrared scan of joints and connections. Remove covers so joints and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison.
1. Instruments and Equipment: Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Instrument: Use infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide documentation of device calibration.

3. Report: Prepare certified report that identifies units checked and that describes scanning results. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

END OF SECTION

SECTION 262913.03
MANUAL AND MAGNETIC MOTOR CONTROLLERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Manual motor controllers.
   2. Enclosed full-voltage magnetic motor controllers.
   3. Combination full-voltage magnetic motor controllers.
   4. Enclosures.
   5. Accessories.
   6. Identification.

1.03 DEFINITIONS

A. CPT: Control power transformer.
B. MCCB: Molded-case circuit breaker.
C. MCP: Motor circuit protector.
D. NC: Normally closed.
E. OCPD: Overcurrent protective device.
F. SCCR: Short-circuit current rating.
G. SCPD: Short-circuit protective device.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
B. Shop Drawings: For each type of magnetic controller.
   1. Include plans, elevations, sections, and mounting details.
   2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
   3. Wire Termination Diagrams and Schedules: Include diagrams for signal, and control wiring. 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. Differentiate between manufacturer-installed and field-installed wiring.
   4. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
C. Product Schedule: List the following for each enclosed controller:
   1. Each installed magnetic controller type.
   2. NRTL listing.
   3. Factory-installed accessories.
   4. Nameplate legends.
   5. SCCR of integrated unit.
   6. For each combination magnetic controller include features, characteristics, ratings, and factory setting of the SCPD and OCPD.
   7. For each series-rated combination state the listed integrated short-circuit current (withstand) rating of SCPD and OCPDs by an NRTL acceptable to authorities having jurisdiction.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Seismic Qualification Data: Certificates, for magnetic controllers, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   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.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For magnetic controllers to include in operation and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. Routine maintenance requirements for magnetic controllers and installed components.
      b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
      c. Manufacturer's written instructions for setting field-adjustable overload relays.
      d. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
      e. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.07 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 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.
   2. Indicating Lights: Two of each type and color installed.
   3. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers.

1.09 FIELD CONDITIONS

A. Ambient Environment Ratings: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   1. Ambient Temperature: Not less than 23 deg F and not exceeding 104 deg F.
   2. Altitude: Not exceeding 6600 feet for electromagnetic and manual devices.
   3. The effect of solar radiation is not significant.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

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 use.

B. UL Compliance: Fabricate and label magnetic motor controllers to comply with UL 508 and UL 60947-4-1.

C. NEMA Compliance: Fabricate motor controllers to comply with ICS 2.

D. Seismic Performance: Magnetic controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the controller will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.02 MANUAL MOTOR CONTROLLERS

A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ABB (Motion Division).
      b. Eaton.
      c. Rockwell Automation, Inc.
      d. Schneider Electric USA (Square D).
      e. Siemens Industry, Inc., Energy Management Division.
   2. Standard: Comply with NEMA ICS 2, general purpose, Class A.
   3. Configuration: Nonreversing.
   4. Pilot light.

B. Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ABB (Electrification Products Division).
      b. ABB (Motion Division).
      c. Eaton.
      d. Rockwell Automation, Inc.
      e. Schneider Electric USA (Square D).
      f. Siemens Industry, Inc., Energy Management Division.
   2. Configuration: Nonreversing.
   3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
   4. Pilot Light

2.03 ENCLOSED FULL-VOLTAGE MAGNETIC MOTOR CONTROLLERS

A. Description: Across-the-line start, electrically held, for nominal system voltage of 600-V ac and less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB (Electrification Products Division).
   2. ABB (Motion Division).
   3. Eaton.
   4. Rockwell Automation, Inc.
   5. Schneider Electric USA (Square D).
   6. Siemens Industry, Inc., Energy Management Division.

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

D. Configuration: Nonreversing.

E. Contactor Coils: Pressure-encapsulated type.
   1. Operating Voltage: Manufacturer's standard, unless indicated.

F. Control Power:
   1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.

G. Overload Relays:
   1. Thermal Overload Relays:
      a. Inverse-time-current characteristic.
      b. Class 20 tripping characteristic.
      c. Heaters in each phase shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
      d. Ambient compensated.
      e. Automatic resetting.

2.04 COMBINATION FULL-VOLTAGE MAGNETIC MOTOR CONTROLLER

A. Description: Factory-assembled, combination full-voltage magnetic motor controller consisting of the controller described in this article, indicated disconnecting means, SCPD and OCPD, in a single enclosure.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB (Electrification Products Division).
   2. ABB (Motion Division).
   3. Eaton.
   4. Rockwell Automation, Inc.
   5. Schneider Electric USA (Square D).
   6. Siemens Industry, Inc., Energy Management Division.

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

D. Configuration: Nonreversing.

E. Contactor Coils: Pressure-encapsulated type.
   1. Operating Voltage: Manufacturer's standard, unless indicated.

F. Control Power:
   1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.

G. Overload Relays:
   1. Thermal Overload Relays:
      a. Inverse-time-current characteristic.
      b. Class 20 tripping characteristic.
      c. Heaters in each phase shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
      d. Ambient compensated.
      e. Automatic resetting.

H. Provide set of Auxiliary contacts

I. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.

J. Fusible Disconnecting Means:
   1. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
   2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

2.05 ENCLOSURES

A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.

B. The construction of the enclosures shall comply with NEMA ICS 6.

2.06 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, except as needed to match enclosure type. Heavy-duty or oil-tight where indicated in the controller schedule.

2.07 IDENTIFICATION

A. Controller Nameplates: as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.

B. Arc-Flash Warning Labels:

1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.
2. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for motor controllers, their relationship with the motors, and other conditions affecting performance of the Work.

3.02 INSTALLATION

A. Comply with NECA 1.

B. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems" unless otherwise indicated.

C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

D. Comply with requirements for seismic control devices specified in Section 260548 "Seismic Controls for Electrical Systems."

E. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

F. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.

3.03 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.
2. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with drawings and specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, and grounding.
   d. Verify the unit is clean.

e. Inspect contactors:
   1) Verify mechanical operation.
   2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.
f. Motor-Running Protection:
   1) Verify overload element rating is correct for its application.
   2) If motor-running protection is provided by fuses, verify correct fuse rating.
g. Inspect bolted electrical connections for high resistance using one of the two following methods:
   1) Use a low-resistance ohmmeter. Compare bolted connection resistance values with values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

C. Motor controller will be considered defective if it does not pass tests and inspections.

END OF SECTION

SECTION 263213.13
DIESEL-ENGINE-DRIVEN GENERATOR SETS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Diesel engine.
   2. Diesel fuel-oil system.
   3. Control and monitoring.
   4. Generator overcurrent and fault protection.
   5. Generator, exciter, and voltage regulator.
   6. Outdoor engine generator enclosure.
   7. Vibration isolation devices.
   8. Generator Tap Box

B. Related Requirements:
   1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.03 DEFINITIONS

A. EPS: Emergency power supply.

B. EPSS: Emergency power supply system.

C. VAC: Volts, alternating current.

D. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   2. Include thermal damage curve for generator.
   3. Include time-current characteristic curves for generator protective device.
   4. Include fuel consumption in gallons per hour at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
   5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
   6. Include airflow requirements for cooling and combustion air in cubic feet per minute at 0.8 power factor, with air-supply temperature of 95, 80, 70, and 50 deg F. Provide Drawings indicating requirements and limitations for location of air intake and exhausts.
   7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:
   1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Identify fluid drain ports and clearance requirements for proper fluid drain.

4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for engine generators and functional relationship between all electrical components.
7. Drawings of generator tap box.

1.05 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: For special warranty.

C. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: With engine and generator mounted on rails, identify center of gravity and total weight, including full fuel tank, supplied enclosure, and each piece of equipment not integral to the engine generator, 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.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
   b. Operating instructions laminated and mounted adjacent to generator location.
   c. Training plan.

1.07 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, subbase fuel tank, engine generator, batteries, battery racks, silencers, sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels.

2.02 MANUFACTURERS

A. Manufacturers: The basis-of-design product is the Kohler 350REOZJC. Subject to compliance with requirements, an equal substitution may be made from one of the following other manufacturers:
   1. Caterpillar
   2. Cummins Power Generation.
   3. Generac.

B. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

2.03 PERFORMANCE REQUIREMENTS

A. B11 Compliance: Comply with B11.19.

B. NFPA Compliance:
   1. Comply with NFPA 37.
   2. Comply with NFPA 70.
   3. Comply with NFPA 110 requirements for Level 1 EPSS.

C. UL Compliance: Comply with UL 2200.

D. Engine Exhaust Emissions: Comply with current EPA requirements and applicable state and local government requirements.

E. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
   1. Ambient Temperature: 5 to 104 deg F.
   2. Relative Humidity: Zero to 95 percent.
   3. Altitude: Sea level to 1000 feet.

2.04 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

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 use.

C. Power Rating: Standby.

D. Service Load: 437.5 kVA.

E. Power Factor: 0.8, lagging.

F. Frequency: 60 Hz.

G. Voltage: 208-V ac.

H. Phase: Three-phase, four wire, wye.

I. Governor: Adjustable isochronous, with speed sensing.

J. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

K. Capacities and Characteristics:
   1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries.
   2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

L. Engine Generator Performance for Sensitive Loads:
   1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
   a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time:
    a. Comply with NFPA 110, Type 10 system requirements.

2.05 DIESEL ENGINE

A. Fuel: ASTM D975, diesel fuel oil, Grade 2-D S15.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid-mounted.
   1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
   2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
   3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499. Must operate at 277 VAC.

E. Integral Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator set mounting frame and integral engine-driven coolant pump.
   1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
   2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.

3. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
4. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.
   a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
   b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer:
1. Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
   a. Minimum sound attenuation of 25 dB at 500 Hz.
   b. Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be 78 dBA or less.

G. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

H. Starting System: electric, with negative ground.
1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level specified.
4. Battery: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
8. Battery Charger: Current-limiting, automatic-equalizing, and float-charging type designed for lead-acid batteries. Unit shall comply with UL 1236 and include the following features:
   a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
   b. Input voltage: 277 VAC, single-phase.
   c. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 to 140 deg F to prevent overcharging at high temperatures and undercharging at low temperatures.
   d. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.

e. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
f. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
g. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.06 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 37.
B. Piping: Fuel-oil piping shall be Schedule 40 black steel. Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.
C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.
D. Fuel Filtering: Remove water and contaminants larger than 1 micron.
E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
F. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:
1. Tank level indicator.
2. Leak detection in interstitial space.
3. Vandal-resistant fill cap.
4. Capacity of fuel tank shall allow for 48 hours of operation of the generator at 100% nameplate load.
5. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.07 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.
B. Provide minimum run time control set for 15 minutes with override only by operation of a remote emergency-stop switch.
C. Comply with UL 508A.
D. Configuration:
1. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.
E. Control and Monitoring Panel:
1. Digital engine generator controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Instruments: Located on the control and monitoring panel and viewable during operation.
a. Engine lubricating-oil pressure gage.
b. Engine-coolant temperature gage.
c. DC voltmeter (alternator battery charging).

d. Running-time meter.
e. AC voltmeter, for each phase.
f. AC ammeter, for each phase.
g. AC frequency meter.
h. Generator-voltage adjusting rheostat.

3. Controls and Protective Devices: Controls, shutdown devices, and common alarm indication, including the following:
   a. Cranking control equipment.
   b. Run-Off-Auto switch.
   c. Control switch not in automatic position alarm.
   d. Overcrank alarm.
   e. Overcrank shutdown device.
   f. Low-water temperature alarm.
   g. High engine temperature prealarm.
   h. High engine temperature.
   i. High engine temperature shutdown device.
   j. Overspeed alarm.
   k. Overspeed shutdown device.
   l. Low fuel main tank.
      1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for duration required for the indicated EPSS class.
   m. Coolant low-level alarm.
   n. Coolant high-temperature alarm.
   o. Coolant low-temperature alarm.
   p. Coolant high-temperature shutdown device.
   q. EPS load indicator.
   r. Battery high-voltage alarm.
   s. Low cranking voltage alarm.
   t. Battery-charger malfunction alarm.
   u. Battery low-voltage alarm.
   v. Lamp test.
   w. Contacts for local and remote common alarm.
   x. Hours of operation.
   y. Engine generator metering, including voltage, current, hertz, kilowatt, kilovolt ampere, and power factor.

F. Connection to Datalink:
   1. Provide connections for datalink transmission of indications to remote data terminals via ModBus RTU. Coordinate with requirements in Section 230923, “Direct Digital Control (DDC) System for HVAC”.

G. Common Remote Panel with Common Audible Alarm: Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

H. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.

2.08 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.

1. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
2. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Overcurrent Protective Device:
1. Molded-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:
a. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
b. Trip Settings: Selected to coordinate with generator thermal damage curve.
c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
d. Mounting: Adjacent to, or integrated with, control and monitoring panel.

2.09 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.
B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
C. Electrical Insulation: Class H.
D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide 12-lead alternator.
E. Range: Provide broad range of output voltage by adjusting the excitation level.
F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
G. Enclosure: Dripproof.
H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.
1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. Maintain voltage within 15 percent on one step, full load.
3. Provide anti-hunt provision to stabilize voltage.
4. Maintain frequency within 5 percent and stabilize at rated frequency within 2 seconds.
5. 2:1 slope.

I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

2.10 OUTDOOR ENGINE GENERATOR ENCLOSURE

A. Description:
1. Vandal-resistant, sound-attenuating, weatherproof steel housing; wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
a. Sound Attenuation Level: 72 dBA at 23 feet from the enclosure.

B. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads up to 100 mph.
C. Seismic Design: Comply with seismic requirements in Section 260548.16 "Seismic Controls for Electrical Systems."
D. Hinged Doors: With padlocking provisions.

E. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine generator components.
F. Muffler Location: Within enclosure.
G. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.
1. Louvers: Fixed-engine, cooling-air inlet and discharge. Stormproof and drainable louvers prevent entry of rain and snow.

2.11 VIBRATION ISOLATION DEVICES

A. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment-mounting and -leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of 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.

B. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.12 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.13 GENERATOR TAP BOX

A. Generator tap box shall provide camlock connections for connection of portable generator set of equal capacity to permanent set.
B. UL 1008
C. Minimum 65 kA withstand rating
D. Meet NFPA 70 requirement
E. Wall-mounted; desired dimensions shown on drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.
B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

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 no fewer than 14 working days in advance of proposed interruption of electrical service. Depending on the timing of the generator

installation, it may be necessary for all interruptions to normal service to be on weekends only.

2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

3.03 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

C. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1. Install packaged engine generator with restrained spring isolators having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. Secure enclosure to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548 "Seismic Controls for Electrical Systems."

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

F. Install generator tap box in accordance with Manufacturer’s written instructions. Comply with Section 260548 "Seismic Controls for Electrical Systems." Terminate all conductors and ground per manufacturer’s instructions.

3.04 CONNECTIONS

A. Connect engine exhaust pipe to engine with flexible connector.

B. Connect fuel piping to engines with a gate valve and union and flexible connector.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

3.05 IDENTIFICATION

A. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.06 FIELD QUALITY CONTROL

A. Testing Agency:

1. Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

2. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.

a. Visual and Mechanical Inspection:

1) Compare equipment nameplate data with Drawings and the Specifications.

2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, and grounding.
4) Verify that the unit is clean.

b. Electrical and Mechanical Tests:
1) Test protective relay devices.
2) Verify phase rotation, phasing, and synchronized operation as required by the application.
3) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
4) Verify correct functioning of the governor and regulator.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.
3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
c. Verify acceptance of charge for each element of the battery after discharge.
d. Verify that measurements are within manufacturer's specifications.
4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.

C. Coordinate tests with tests for transfer switches and run them concurrently.
D. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.
E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.
F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.
G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
H. Remove and replace malfunctioning units and retest as specified above.
I. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.
J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.07 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION

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SECTION 263213.16
GAS-ENGINE-DRIVEN GENERATOR SETS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Gas-engine-driven generator sets.
   2. Gas engine.
   3. Gas fuel system.
   4. Control and monitoring.
   5. Generator overcurrent and fault protection.
   6. Generator, exciter, and voltage regulator.
   7. Outdoor generator-set enclosure.
   8. Vibration isolation devices.

B. Related Requirements:
   1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.02 DEFINITIONS

A. EPS: Emergency power supply.

B. EPSS: Emergency power supply system.

C. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   2. Include thermal damage curve for generator.
   3. Include time-current characteristic curves for generator protective device.
   4. Include fuel consumption in cubic feet per hour (cubic meters per hour) at 0.8 power factor at 0.5, 0.75 and 1.0 times generator capacity.
   5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
   6. Include air flow requirements for cooling and combustion air in cfm at 0.8 power factor, with air supply temperature of 95 deg F, 80 deg F, 70 deg F, and 50 deg F. Provide drawings showing requirements and limitations for location of air intake and exhausts.
   7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:
   1. Include plans and elevations for engine generator and other components specified.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Identify fluid drain ports and clearance requirements for proper fluid drain.
   4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.

6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.04 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: With engine and generator mounted on rails, identify center of gravity and total weight, supplied enclosure, and each piece of equipment not integral to the engine generator, 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.

B. Source Quality-Control Reports: Including, but not limited to, the following:
   1. Certified summary of prototype-unit test report.
   2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
   3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
   4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
   5. Report of sound generation.
   6. Report of exhaust emissions showing compliance with applicable regulations.
   7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

C. Field quality-control reports.

D. Warranty: For special warranty.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For engine generators to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
      b. Operating instructions laminated and mounted adjacent to generator location.
      c. Training plan.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.07 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 GAS-ENGINE-DRIVEN GENERATOR SETS

A. Manufacturers: The basis-of-design product is the Kohler 350REZXD. Subject to compliance with requirements, an equal substitution may be made from one of the following other manufacturers:
   1. Caterpillar
   2. Cummins Power Generation.
   3. Generac.

B. Source Limitations: Obtain packaged engine generators and auxiliary components through one source from a single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, engine generator, batteries, battery racks, silencers,and sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels.

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:
   1. Comply with NFPA 37.
   2. Comply with NFPA 70.
   3. Comply with NFPA 99.
   4. Comply with NFPA 110 requirements for Level 1 EPSS.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: Comply with current EPA requirements and applicable state and local government requirements.

F. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
   1. Ambient Temperature: 5 to 104 deg F.
   2. Relative Humidity: Zero to 95 percent.
   3. Altitude: Sea level to 1000 feet.

2.03 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and use.

C. Power Rating: Standby.

D. Service Load: 437.5 kVA.

E. Power Factor: 0.8, lagging.

F. Frequency: 60 Hz.

G. Voltage: 208 V ac.

H. Phase: Three-phase, four wire, wye.

I. Governor: Adjustable isochronous, with speed sensing.

J. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

K. Capacities and Characteristics:
   1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries.
   2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

L. Engine Generator Performance for Sensitive Loads:
   1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
      a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
   2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
   3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
   4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
   5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
   6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
   7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
   8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
   9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
      a. Provide permanent magnet excitation for power source to voltage regulator.
   10. Start Time:
      a. 10 seconds.

2.04 GAS ENGINE

A. Fuel: Natural gas.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid-mounted.
   1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
   2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.

3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499 and with NFPA 110 requirements for Level 1 equipment for heater capacity.

E. Integral Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.
   1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
   2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
   3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
   4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
   5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
      a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
      b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer:
   1. Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
      a. Minimum sound attenuation of 25 dB at 500 Hz.
      b. Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be 78 dBA or less.

G. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

H. Starting System:electric, with negative ground.
   1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
   2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
   3. Cranking Cycle: [As required by NFPA 110 for system level specified] [60 seconds].
   4. Battery: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice without recharging.
   5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
   6. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35 A minimum continuous rating.

7. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for lead-acid batteries. Unit shall comply with UL 1236 and include the following features:
   a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
   b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg F to 140 deg F to prevent overcharging at high temperatures and undercharging at low temperatures.
   c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
   d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
   e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
   f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.05 GAS FUEL SYSTEM

A. Natural Gas Piping: Comply with requirements in Section 231123 "Facility Natural Gas Piping."
B. Gas Train: Comply with NFPA 37.
C. Engine Fuel System:
   1. Vapor-Withdrawal System:
      a. Carburetor.
      b. Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.
      c. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.
   2. Fuel Filters: One for each fuel type.
   3. Manual Fuel Shutoff Valves: One for each fuel type.
   4. Flexible Fuel Connectors: Minimum one for each fuel connection.

2.06 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates generator-set shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.
B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates generator-set shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.
C. Provide minimum run time control set for 15 minutes with override only by operation of a remote emergency-stop switch.

D. Comply with UL 508A.

E. Configuration:

1. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from generator-set vibration. Panel shall be powered from the engine generator battery.
2. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.
3. Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel shall be powered from the engine generator battery.

F. Control and Monitoring Panel:

1. Digital controller with integrated LCD, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
3. Instruments: Located on the control and monitoring panel and viewable during operation.
   a. Engine lubricating-oil pressure gage.
   b. Engine-coolant temperature gage.
   c. DC voltmeter (alternator battery charging).
   d. Running-time meter.
   e. AC voltmeter, for each phase.
   f. AC ammeter, for each phase.
   g. AC frequency meter.
   h. Generator-voltage adjusting rheostat.
4. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication, including the following:
   a. Cranking control equipment.
   b. Run-Off-Auto switch.
   c. Control switch not in automatic position alarm.
   d. Overcrank alarm.
   e. Overcrank shutdown device.
   f. Low water temperature alarm.
   g. High engine temperature prealarm.
   h. High engine temperature.
   i. High engine temperature shutdown device.
   j. Overspeed alarm.
   k. Overspeed shutdown device.
   l. Coolant low-level alarm.
   m. Coolant low-level shutdown device.
   n. Coolant high-temperature prealarm.
   o. Coolant high-temperature alarm.
   p. Coolant low-temperature alarm.
   q. Coolant high-temperature shutdown device.
   r. EPS supplying load indicator.

s. Battery high-voltage alarm.
t. Low cranking voltage alarm.
u. Battery-charger malfunction alarm.
v. Battery low-voltage alarm.
w. Lamp test.
x. Contacts for local and remote common alarm.
y. Hours of operation.
z. Engine generator metering, including voltage, current, Hz, kW, kVA, and power factor.
aa. Generator overcurrent protective device not closed alarm.

G. Connection to Datalink:
1. Provide connections for datalink transmission of indications to remote data terminals via ModBus RTU. Data system connections to terminals are covered in Section 260913 "Electrical Power Monitoring and Control."

H. Common Remote Panel with Common Audible Alarm: Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

I. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

J. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

2.07 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.
1. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
2. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Overcurrent Protective Device:
1. Molded-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:
a. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
b. Trip Settings: Selected to coordinate with generator thermal damage curve.
c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
d. Mounting: Adjacent to or integrated with control and monitoring panel.

2.08 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide 12 lead alternator.

E. Range: Provide broad range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
G. Enclosure: Dripproof.
H. Instrument Transformers: Mounted within generator enclosure.
I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.
   1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
   2. Maintain voltage within 15 percent on one step, full load.
   3. Provide anti-hunt provision to stabilize voltage.
   4. Maintain frequency within 5 percent and stabilize at rated frequency within 2 seconds.
J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
L. Subtransient Reactance: 12 percent, maximum.

2.09 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description:
   1. Vandal-resistant, sound-attenuating, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
      a. Sound Attenuation Level: 72 dBA at 23 feet from the enclosure .
B. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads up to 100 mph.
C. Seismic Design: Comply with seismic requirements in Section 260548.16 "Seismic Controls for Electrical Systems."
D. Hinged Doors: With padlocking provisions.
E. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine generator components.
F. Muffler Location: Within enclosure.
G. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
   1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
H. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

2.10 VIBRATION ISOLATION DEVICES

A. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

   1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
   2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of 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.

2.11 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

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

3.02 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

C. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. Install packaged engine generator with elastomeric isolator pads having a minimum deflection of 1 inch on 4-inch-high concrete base. Secure engine generator to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548 "Seismic Controls for Electrical Systems."

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel piping adjacent to packaged engine generator to allow service and maintenance.

C. Connect engine exhaust pipe to engine with flexible connector.

D. Gaseous Fuel Connections:

1. Connect fuel piping to engines with a gate valve and union and flexible connector.
2. Install manual shutoff valve in a remote location to isolate gaseous fuel supply to the generator.
3. Vent gas pressure regulators outside building a minimum of 60 inches from building openings.

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

3.04 IDENTIFICATION

A. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.05 FIELD QUALITY CONTROL

A. Testing Agency:
   1. Engage a qualified testing agency to perform tests and inspections.
   2. Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:
   1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.
      a. Visual and Mechanical Inspection:
         1) Compare equipment nameplate data with Drawings and the Specifications.
         2) Inspect physical and mechanical condition.
         3) Inspect anchorage, alignment, and grounding.
         4) Verify that the unit is clean.
   2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.
   3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
      a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
      b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
      c. Verify acceptance of charge for each element of the battery after discharge.
      d. Verify that measurements are within manufacturer's specifications.
   4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
   5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest as specified above.

I. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION

SECTION 263353
STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. UPS systems.
   2. Surge suppression.
   3. Rectifier-charger.
   4. Inverter.
   5. Controls and indications.
   6. Maintenance bypass/isolation switch.
   7. Battery.
   8. Basic battery monitoring.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.02 DEFINITIONS

A. GTO: Gate turn-off thyristor.
B. IGBT: Isolated gate bipolar transistor.
C. PF: Power factor.
D. pF: Picofarads.
E. THD: Total harmonic distortion.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of UPS.
   1. UPS systems.
   2. Surge suppression.
   3. Rectifier-charger.
   4. Inverter.
   5. Controls and indications.
   6. Maintenance bypass/isolation switch.
   7. Remote status and alarm panel.
   8. Battery.
   9. Basic battery monitoring.

B. Shop Drawings: For UPS.
   1. Include plans, elevations, sections, and mounting details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
   4. Include diagrams for power, signal, and control wiring.

C. Field quality-control reports.

1.04 INFORMATIONAL SUBMITTALS

A. Manufacturers' published instructions.
B. Field Reports:

1. Factory test reports.
2. Manufacturer's field reports for field quality-control support.

1.05 CLOSEOUT SUBMITTALS

A. Performance Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

1.06 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.

B. Spare Parts: Furnish to Owner spare parts, for repairing UPS system, that are packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:
   1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.

C. Consumable Items:
   1. After completion of field quality control, startup, commissioning, adjusting, and closeout activities, replace air filters.
   2. Furnish to Owner extra consumable items for storage on-site, identified with labels describing contents. Include the following:
      a. Cabinet Ventilation Filters: One complete set(s).

1.07 WARRANTY FOR UPS SYSTEM

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed UPS system performs in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
   1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.

1.08 WARRANTY FOR BATTERIES

A. Special Manufacturer Extended Warranty for Batteries: Manufacturer warrants that batteries perform in accordance with specified requirements and agrees to provide repair or replacement of batteries that fail to perform as specified within extended-warranty period.
   1. Initial Extended-Warranty Period for Li-Ion Batteries: Five years from date of Substantial Completion; full coverage for materials only, free on board destination, freight prepaid.

PART 2 - PRODUCTS

2.01 OPERATIONAL REQUIREMENTS

A. Automatic operation includes the following:
   1. Double Conversion, Line Interactive:
      a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, with the rectifier-charger and inverter turned off and the battery disconnected.
      b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the rectifier-charger and inverter turn on and the battery supplies energy to provide constant, regulated inverter power output to the load with minimum of 98 percent UPS system efficiency.
      c. Power Failure: If normal power fails, there is a maximum 4 µs delay while the rectifier-charger and inverter turn on and the battery supplies energy to re-establish constant, regulated power output to the load.
   2. When power is restored at the normal supply terminals of the system, controls must automatically synchronize the inverter with the external source before transferring

the load. The rectifier-charger must supply power to the load through the inverter and simultaneously recharge the battery.

3. If the battery becomes discharged and normal supply is available, the rectifier-charger must charge the battery. The rectifier-charger must automatically shift to float-charge mode on reaching full charge.
4. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch must switch the load to the normal AC supply circuit without disturbance or interruption.
5. The output power converters must produce up to 300 percent of rated full-load current for short-circuit clearing. The inverter must sustain steady-state overload conditions of up to 200 percent of rated full-load current 200 milliseconds in normal operation.
6. The inverter must be capable of sustaining 150 percent of system capacity for 30 seconds while powered from the battery.
7. Should overloads persist past the time limitations, the automatic static transfer switch must switch the load to the bypass output of the UPS. When the fault has cleared, the static bypass transfer switch must return the load to the UPS system.
8. If the battery is disconnected, the UPS must supply power to the load from the normal supply with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following:
1. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal AC supply circuit without disturbance or interruption.
2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions described below without interrupting supply to the load during switching:
1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS AC input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS AC supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
3. Normal: Normal UPS AC supply terminals are energized and the load is supplied through the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

2.02 PERFORMANCE REQUIREMENTS

A. UL Compliance: Listed and labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with UL 1778.

B. NFPA Compliance: UPS components must be listed and labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, as suitable for installation in computer rooms in accordance with NFPA 75.

C. The UPS must perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a maximum load crest factor of 3.0, under the following conditions or combinations of the following conditions:
1. Inverter is switched to battery source.

2. Steady-state AC input voltage deviates up to plus or minus 10 percent from nominal voltage.
3. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
5. Load is 30 percent unbalanced continuously.

D. Minimum Duration of Supply: If battery is sole energy source supplying rated full-load UPS current at 1.0 power factor, duration of supply is 15 minutes.

E. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state AC input voltage varies plus 10 percent and minus 15 percent from nominal voltage.

F. Overall UPS Efficiency: Equal to or greater than 94 percent at 100 percent load, 94 percent at 75 percent load, and 93 percent at 25 percent load.

G. Maximum Energizing Inrush Current: Six times the full-load current.

H. AC Output-Voltage Regulation for Loads 100 Percent Unbalanced: Maximum of plus or minus 2 percent over the full range of battery voltage.

I. AC Output-Voltage Regulation for Loads 100 Percent Balanced: Maximum of plus or minus 1 percent over the full range of battery voltage.

J. Output Frequency: 60 Hz, plus or minus 0.1 percent over the full range of input voltage, load, and battery voltage.

K. Limitation of harmonic distortion of input current to the UPS must be as follows:
1. Rectifier-charger circuits must limit THD to 5 percent, maximum, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30. Provide tuned harmonic filter if required to meet harmonic distortion limit.
2. THD is limited to a maximum of 32 percent, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30.

L. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent RMS total and 3 percent RMS for any single harmonic, for 100 percent rated nonlinear load current, with a load crest factor of 3.0.

M. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, 200 percent for 60 seconds in normal operation, and 150 percent for 30 seconds in battery operating mode.

N. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage must remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 50 ms:
1. 50 Percent: Plus or minus 3 percent.
2. 100 Percent: Plus or minus 5 percent.
3. Loss of AC Input Power: Plus or minus 1 percent.
4. Restoration of AC Input Power: Plus or minus 1 percent.

O. Input Power Factor: A minimum of 0.90 lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current without additional filters.

2.03 UPS SYSTEMS

A. Description: Self-contained, battery backup device and accessories that provides three-phase electrical power in the event of failure or sag in the normal power system.

B. Manufacturers: Vertiv/Liebert APM2 is the Basis-of-design product. Subject to compliance with requirements, one of the following may be provided as a substitution.

1. APC by Schneider Electric.
2. Eaton.

C. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.

D. Enclosures: Comply with IP20 enclosure, designed for floor-mounting.

E. Configuration: Multicabinet modular style units.

F. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.

G. Maintainability Features: Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.

H. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

I. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future 25 percent increase in UPS capacity.

J. Seismic-Restraint Design: UPS assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) must be designed and fabricated to withstand static and seismic forces.

K. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.

L. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

2.04 SURGE SUPPRESSION

1. The UPS shall have built-in protection against surges, sags, and overcurrent from the AC source. The protection shall meet the requirements specified in standards ANSI C62.41 B3 including C62.41.1 and C62.41.2.

2.05 RECTIFIER-CHARGER

A. Description: Voltage source converter, IGBT rectifier.

B. The rectifier/charger shall be capable of supplying an additional 20% power for recharging a fully discharged DC stored energy source for charging current with UPS at full load and input voltage at nominal. After the stored energy source is recharged, the rectifier/charger shall maintain the source at full charge until the next emergency operation.

C. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.

D. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.

E. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.

1. Response Time: Field adjustable for maximum compatibility with local generator-set power source.

F. Battery Float-Charging Conditions: Comply with battery manufacturer's published instructions for battery terminal voltage and charging current required for maximum battery life. The battery charger must be matched to the battery type supplied.

G. The term DC-DC converter shall denote the equipment and controls to regulate the output of the rectifier to the levels appropriate for charging the battery and to boost the battery voltage to the level required to operate the inverter. The DC-DC converter shall be solid-state, capable of providing rated output power and, for increased performance, shall be a pulse width- modulated design and shall utilize insulated gate bipolar transistors (IGBTs). The DC-DC converter shall control charging of the battery.

2.06 INVERTER

A. Description:
   1. Pulse-width modulated, IGBT with sinusoidal output.
   2. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

2.07 CONTROLS AND INDICATIONS

A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.

B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.

C. Indications: Plain-language messages on a digital LCD.
   1. Quantitative indications must include the following:
      a. Input voltage, each phase, line to line.
      b. Input current, each phase, line to line.
      c. Bypass input voltage, each phase, line to line.
      d. Bypass input frequency.
      e. System output voltage, each phase, line to line.
      f. System output current, each phase.
      g. System output frequency.
      h. DC bus voltage.
      i. Battery current and direction (charge/discharge).
      j. Elapsed time discharging battery.
   2. Basic status condition indications must include the following:
      a. Normal operation.
      b. Load-on bypass.
      c. Load-on battery.
      d. Inverter off.
      e. Alarm condition.
   3. Alarm indications must include the following:
   4. The following alarm messages shall be displayed:
      • Mains Voltage Abnormal.
      • Mains Under voltage.
      • Mains Freq. Abnormal.
      • Charger Fault.
      • Battery Reversed.
      • No Battery.
      • Parallel Comm. Fail.
      • Bypass Unable to Track.
      • Bypass Abnormal.
      • Inverter Asynchronous.
      • Fan Fault.
      • Control Power Fail.

- Unit Overload.
- System Overload.
- Bypass Phase Reversed.
- Transfer Time-Out.
- Load Sharing Fault.
- Bypass Over Current.
- DC Cap Life Pre-warning.
- DC Cap Life Warning.
- Fan Life Pre-warning.
- Fan Life Warning.
- Intelligent Parallel Mode Active.
- Input Neutral Lost.
- Loss of Redundancy.
- Multi Module System Inverter Manual ON.Controls must include the following:

a. Inverter on-off.
b. UPS start.
c. Battery test.
d. Alarm silence/reset.
e. Output-voltage adjustment.

D. Dry-form "C" contacts must be available for remote indication of the following conditions:
1. UPS on battery.
2. UPS on-line.
3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

E. Emergency Power off Switch: Capable of local operation and operation by means of activation by external dry contacts.

2.08 MAINTENANCE BYPASS/ISOLATION SWITCH

A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.
1. Switch must be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
2. Switch must electrically isolate other UPS components to permit safe servicing.
3. Switch must electrically isolate the rectifier-charger, inverter, and static bypass transfer switch from the load, but must allow primary power to the UPS for testing.

B. Comply with NEMA PB 2 and UL 891.

C. Switch Rating: Continuous duty at rated full-load UPS current.

D. Mounting Provisions: Internal to system cabinet.

E. Key interlock with key that is released only when the rectifier-charger and inverter are bypassed by the static bypass transfer switch. Key must be required to unlock maintenance bypass/isolation switch before switching from open (normal) position to closed position. Lock must be designed specifically for mechanical and electrical component interlocking.

2.09 REMOTE STATUS AND ALARM PANEL

A. Description: Labeled LEDs on panel faceplate indicating five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.

1. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.

2.10 BATTERY

A. General Characteristics:
   1. Lithium ion units, factory assembled in an isolated compartment of UPS cabinet, complete with battery disconnect switch.
      a. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

B. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) must be designed and fabricated to withstand static and seismic forces.

2.11 BASIC BATTERY MONITORING

A. Basic Battery Monitoring: Continuous, real-time capture of battery performance data.

B. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 µ.

C. Annunciation of Alarms: At UPS control panel and remotely.

2.12 SOURCE QUALITY CONTROL

A. Product Data: Prepare and submit catalog cuts, brochures, diagrams, and performance data illustrating size, physical appearance, and other characteristics of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for UPS.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   3. Product Certificates: For each product, from manufacturer.
   4. Sample Warranties: For manufacturer's special warranties.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for conditions affecting performance of the UPS.

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

C. Verify installation conditions are representative of the conditions used in the coordination studies for the electrical system. Provide fuse protection in accordance with Section 262813 "Fuses" if required for coordination with UPS overcurrent protective device requirements.

3.02 INSTALLATION

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
   1. Install plenum cable in environmental air spaces, including plenum ceilings.
   2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
   3. Comply with requirements for raceways and boxes specified in Section 260533.13 "Conduits for Electrical Systems."
   4. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

C. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. 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 concrete base 6 inch from the outer edge of the 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.

D. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's published instructions and NFPA 70.

E. Connections: Interconnect system components. Make connections to supply and load circuits in accordance with manufacturer's wiring diagrams unless otherwise indicated. Apply oxide inhibitor on battery terminals.

3.03 GROUNDING

A. Separately Derived Systems:
1. If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
2. If part of a listed power supply for a data-processing room, comply with manufacturer's published instructions that include grounding requirements in excess of NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.04 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
1. Identify each battery cell individually.

3.05 BATTERY EQUALIZATION

A. Equalize charging of battery cells in accordance with manufacturer's published instructions. Record individual-cell voltages.

3.06 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Inspect interiors of enclosures, including the following:
   a. Inspect anchorage, alignment, grounding, and required clearances.
   b. Component type and labeling verification.
   c. Ratings of installed components.
2. Test electrical and mechanical interlock systems for correct operation and sequencing.
3. Inspect bolted electrical connections for high resistance using one or more of the following methods:
   a. Use of low-resistance ohmmeter in accordance with Section 7.22.2.2 of NETA ATS.
   b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published instructions or Table 100.12 of NETA ATS.
   c. Perform thermographic survey in accordance with Section 9 of NETA ATS.
4. Test static transfer from inverter to bypass and back. Use normal load, if possible.

5. Test DC undervoltage trip level on inverter input breaker. Set in accordance with manufacturer's published instructions.
6. Verify synchronizing indicators for static switch and bypass switches.
7. Test insulated-case and molded-case breakers.
   a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published instructions. In the absence of manufacturer's published instructions, use Table 100.1 of NETA ATS.
   b. Perform insulation-resistance tests on all control wiring for ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components, follow manufacturer's recommendation.
   c. Use primary current injection to determine long time and short time, ground fault, and instantaneous pickup, Use secondary current injection to test trip functions.
   d. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published instructions.
   e. Verify operation of charging mechanism.
   f. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function, and trip unit battery condition. Reset all trip logs and indicators.
8. Test direct current system's batteries.
   a. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
   b. Inspect spill containment installation. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
   c. Verify all charger functions and alarms.
   d. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
   e. Perform a load test in accordance with manufacturer's published instructions or IEEE 450.
   f. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
   g. Test values.
      1) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
      2) Charger float and equalize voltage levels must be in accordance with battery manufacturer's published instructions.
      3) The results of charger functions and alarms must be in accordance with manufacturer's published instructions.
      4) Cell voltages must be within 0.05 V of each other or in accordance with manufacturer's published instructions.
      5) Cell internal ohmic values (resistance, impedance, or conductance) must not vary by more than 25 percent between identical cells that are in a fully charged state.
      6) Results of load tests must be in accordance with manufacturer's published instructions or IEEE 450.
9. Test communication of status and alarms to remote monitoring equipment.

10. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for unit's rating. Use instruments calibrated within the previous six months in accordance with NIST standards.
    a. Simulate malfunctions to verify protective device operation.
    b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
    c. Test harmonic content of input and output current at 25, 50, and 100 percent of rated loads.
    d. Test output voltage under specified transient-load conditions.
    e. Test efficiency at 50, 75, and 100 percent of rated loads.
    f. Test remote status and alarm panel functions.
    g. Test battery-monitoring system functions.

B. Seismic-restraint tests and inspections must include the following:
    1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.
    2. Test mounting and anchorage devices in accordance with requirements in Section 260548 "Seismic Controls for Electrical Systems."

C. Nonconforming Work:
    1. The UPS system will be considered defective if it does not pass tests and inspections.
    2. Remove and replace defective units and retest.

D. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports. Include references to manufacturers' published instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

3.07 PERFORMANCE TESTING

A. Engage the services of a qualified power quality specialist to perform tests and activities indicated for each UPS system.

B. Monitoring and Testing Schedule: Perform monitoring and testing in a single 10-day period.
    1. Schedule monitoring and testing activity with Owner, through Architect, with at least 14 days' advance notice.
    2. Schedule monitoring and testing after Substantial Completion, when the UPS is supplying power to its intended load.

C. Monitoring and Testing Instruments: Three-phase, recording, power monitors. Instruments must provide continuous simultaneous monitoring of electrical parameters at UPS input terminals and at input terminals of loads served by the UPS. Instruments must monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power-line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments must be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:
    1. Current: Each phase and neutral and grounding conductors.
    2. Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
    3. Frequency transients.
    4. Voltage swells and sags.
    5. Voltage Impulses: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
    6. High-frequency noise.
    7. Radio-frequency interference.

8. THD of the above currents and voltages.
9. Harmonic content of currents and voltages above.
10. Battery cell temperature during charging.
11. Ambient temperature.

D. Monitoring and Testing Procedures:
1. Exploratory Period: For the first two days of the first scheduled monitoring and testing period, make recordings at various circuit locations and with various parameter-threshold and sampling-interval settings. Make these measurements with the objective of identifying optimum UPS, power system, load, and instrumentation setup conditions for subsequent test and monitoring operations.
2. Remainder of Test Period: Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.
a. Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the UPS for values indicated, and to highlight the need to adjust, repair, or modify the UPS, distribution system, or load component that may influence its performance or that may require better power quality.
b. Perform load and UPS power source switching and operate the UPS on generator power during portions of test period in accordance with directions of Owner's power quality specialist.
c. Operate the UPS and its loads in each mode of operation permitted by UPS controls and by the power distribution system design.
d. Using loads and devices available as part of the facility's installed systems and equipment, create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
e. Using temporarily connected resistive/inductive load banks, create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
f. Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing; repeat appropriate monitoring and testing to verify success of corrective action.

E. Coordination with Specified UPS Monitoring Functions: Obtain printouts of built-in monitoring functions specified for the UPS and its components in this Section that are simultaneously recorded with portable instruments in this article.
1. Provide the temporary use of an appropriate PC and printer equipped with required connections and software for recording and printing if such units are not available on-site.
2. Coordinate printouts with recordings for monitoring performed in accordance with this article, and resolve and report any anomalies in and discrepancies between the two sets of records.

F. Monitoring and Testing Assistance by Contractor:
1. Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement and removal as requested.
2. Observe monitoring and testing operations; ensure that UPS and distribution and load equipment warranties are not compromised.

3. Perform switching and control of various UPS units, electrical distribution systems, and load components as directed by power quality specialist. Specialist must design this portion of monitoring and testing operations to expose the UPS to various operating environments, conditions, and events while response is observed, electrical parameters are monitored, and system and equipment deficiencies are identified.
4. Make repairs and adjustments to the UPS and to electrical distribution system and load components, and retest and repeat monitoring as needed to verify validity of results and correction of deficiencies.
5. Engage the services of the UPS manufacturer's factory-authorized service representative periodically during performance testing operations for repairs, adjustments, and consultations.

G. Documentation: Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording. Coordinate simultaneous recordings made on UPS input and load circuits.

H. Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following inreport:
1. Descriptions of corrective actions performed during monitoring and survey work and their results.
2. Recommendations for further action to provide optimum performance by the UPS and appropriate power quality for non-UPS loads. Include a statement of priority ranking and a cost estimate for each recommendation that involves system or equipment revisions.
3. Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents.
4. Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations.
5. Recommendations for operating, adjusting, or revising UPS controls.
6. Recommendations for alterations to the UPS installation.
7. Recommendations for adjusting or revising generator-set or automatic transfer switch installations or their controls.
8. Recommendations for power distribution system revisions.
9. Recommendations for adjusting or revising electrical loads, their connections, or controls.

I. Interim and Final Reports: Provide an interim report at the end of each test period and a final comprehensive report at the end of final test and analysis period.

END OF SECTION

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SECTION 263600
TRANSFER SWITCHES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Contactor-type automatic transfer switches.

1.02 ACTION SUBMITTALS

A. Product Data:
   1. Contactor-type automatic transfer switches.

B. Product Data Submittals: For each product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
   2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

C. Shop Drawings:
   1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
   2. Include material lists for each switch specified.
   3. Single-Line Diagram: Show connections between transfer switch,power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

1.03 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Seismic Qualification Data: Certificates, for transfer switches, accessories, and components, from manufacturer.

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   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.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. Features and operating sequences, both automatic and manual.
      b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.05 QUALITY ASSURANCE

A. Testing Agency Qualifications:
   1. Member company of NETA.
      a. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.06 FIELD 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:

1. Notify Construction Manager no fewer than 14 days in advance of proposed interruption of electrical service. Note that it may be necessary to perform outage during weekend hours.
2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

1.07 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

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. Comply with NEMA ICS 1.
C. Comply with NFPA 110.
D. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
E. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
   1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
   2. Short-time withstand capability for three cycles.
F. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
G. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
H. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.
I. Neutral Terminal: Solid and fully rated unless otherwise indicated.
J. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable with printed markers at terminations. Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."
   1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
   2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
   3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
   4. Accessible via front access.
K. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, where indoors. NEMA 250, Type 3R, where outdoors.

2.02 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Caterpillar, Inc.; Electric Power Division.
   2. Cummins Power Generation.
   3. Eaton.
   4. Generac.
   5. Kohler Power Systems.
   6. Russelectric, Inc.

B. Comply with Level 1 equipment according to NFPA 110.

C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
   1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
   2. Switch Action: Double throw; mechanically held in both directions.
   3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
   4. Conductor Connectors: Suitable for use with conductor material and sizes.
   5. Material: Tin-plated aluminum.
   6. Main and Neutral Lugs: Mechanical type.
   7. Ground Lugs and Bus-Configured Terminators: Mechanical type.
   8. Ground bar.
   9. Connectors shall be marked for conductor size and type according to UL 1008.

D. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.
   1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

E. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

F. Automatic Transfer-Switch Controller Features:
   1. Controller operates through a period of loss of control power.
   2. Undervoltage Sensing for Each Phase of NormalSource: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
   3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
   4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
   5. Test Switch: Simulate normal-source failure.
   6. Switch-Position Pilot Lights: Indicate source to which load is connected.
   7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
10. Engine Shutdown Contacts:
    a. Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
11. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is unavailable.
12. For Gen-Gen transfer switch, controls shall have the ability to flip-flop operation of generator each time it is called for.

2.03 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. 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

3.01 INSTALLATION

A. Mount transfer switches securely to structure utilizing 5/8 inch channel.
B. Mount ground-mounted switches on concrete base, where outdoors, our housekeeping pad, where indoors.
C. Identify components according to Section 260553 "Identification for Electrical Systems."
D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.
E. Comply with NECA 1.
F. Comply with requirements for seismic control devices specified in Section 260548 "Seismic Controls for Electrical Systems."

3.02 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets,control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.
B. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.
    1. Comply with requirements for raceways specified in Section 260533.13 "Conduits for Electrical Systems."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
F. Connect twisted pair cable according to Section 260523 "Control-Voltage Electrical Power Cables."
G. Route and brace conductors according to manufacturer's written instructions and Section 260529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.
H. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches in length.
I. Brace and support equipment according to Section 260548.16 "Seismic Controls for Electrical Systems."

3.03 FIELD QUALITY CONTROL

A. Administrant for Tests and Inspections:
   1. Engage qualified testing agency to administer and perform tests and inspections.
B. Tests and Inspections:
   1. After installing equipment, test for compliance with requirements according to NETA ATS.
   2. Visual and Mechanical Inspection:
      a. Compare equipment nameplate data with Drawings and Specifications.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding, and required clearances.
      d. Verify that the unit is clean.
      e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
      f. Verify that manual transfer warnings are attached and visible.
      g. Verify tightness of all control connections.
      h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:
         1) Use of low-resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
      i. Perform manual transfer operation.
      j. Verify positive mechanical interlocking between normal and alternate sources.
      k. Perform visual and mechanical inspection of surge arresters.
      l. Inspect control power transformers.
         1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
         2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
         3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.
   3. Electrical Tests:
      a. Perform insulation-resistance tests on all control wiring with respect to ground.
      b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.

c. Verify settings and operation of control devices.
d. Calibrate and set all relays and timers.
e. Verify phase rotation, phasing, and synchronized operation.
f. Perform automatic transfer tests.
g. Verify correct operation and timing of the following functions:
1) Normal source voltage-sensing and frequency-sensing relays.
2) Engine start sequence.
3) Time delay on transfer.
4) Alternative source voltage-sensing and frequency-sensing relays.
5) Automatic transfer operation.
6) Interlocks and limit switch function.
7) Time delay and retransfer on normal power restoration.
8) Engine cool-down and shutdown feature.

4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
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.
d. Perform manual transfer operation.

5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and 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 retransfer from emergency source with normal source available.
b. Verify time-delay settings.
c. Verify pickup and dropout voltages by data readout or inspection of control settings.
d. 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 shutdown.

C. Coordinate tests with tests of generator and run them concurrently.
D. Report results of tests and inspections in writing. 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.
E. Transfer switches will be considered defective if they do not pass tests and inspections.
F. Remove and replace malfunctioning units and retest as specified above.
G. Prepare test and inspection reports.
H. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.04 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

END OF SECTION

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SECTION 264113
LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.01 SUMMARY AND SCOPE

A. Section Includes: Lightning protection system for ordinary structures.

B. Section Includes: Lightning protection system for the following:

1. Ordinary structures.

C. Scope of the delegated lighting protection system design and implementation shall extend to all portions of the existing building, addition, radio shop, and other structures above 10’ tall on site.

1.02 ACTION SUBMITTALS

A. Product Data: For each product.

B. Shop Drawings:

1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
2. Include raceway locations needed for the installation of conductors.
3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
4. Include roof attachment details, coordinated with roof installation.
5. Calculations required by NFPA 780 for bonding of metal bodies.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lightning protection cabling attachments to roofing systems and accessories.
2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.

B. Qualification Data: For Installer.

C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.

D. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance Data: For lightning protection system to include in maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations. Comply with requirements of Section 017839 "Project Record Documents."
   b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.

B. Completion Certificate:

1. UL Master Label Certificate.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: UL-listed installer, category OWAY.

PART 2 - PRODUCTS

2.01 LIGHTNING PROTECTION FOR STRUCTURES

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

1. ERICO; brand of nVent Electrical plc.
2. Harger Lightning & Grounding; business of Harger, Inc.
3. National Lightning Protection.
4. Thompson Lightning Protection, Inc.
5. VFC Lightning Protection.

2.02 PERFORMANCE REQUIREMENTS

A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I buildings.

B. UL Lightning Protection Standard: Comply with UL 96A requirements for Class I buildings.

C. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

2.03 MATERIALS

A. Air Terminals:
1. Copper unless otherwise indicated.
2. 5/8-inch diameter by 18 inches long.
3. Rounded tip.
4. Threaded base support.

B. Air Terminal Bracing:
1. Copper.
2. 1/4-inch diameter rod.

C. Class I Main Conductors:
1. Stranded Copper: 57,400 circular mils in diameter.

D. Class II Main Conductors:
1. Stranded Copper: 115,000 circular mils in diameter.

E. Secondary Conductors:
1. Stranded Copper: 26,240 circular mils in diameter.

F. Ground Loop Conductor: Stranded copper.

G. Ground Rods:
1. Material: Copper-clad steel.
2. Diameter: 3/4 inch.
3. Rods shall be not less than 120 inches long.

H. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install lightning protection components and systems according to UL 96A.

B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.

C. Conceal conductors within normal view from exterior locations at grade within 200 feet of building. Comply with requirements for concealed installations in UL 96A.
1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies

with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.

2. Install conduit where necessary to comply with conductor concealment requirements.
3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.02 CONNECTIONS

A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: exothermic weld.

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 bonding so vibration is not transmitted to rigidly mounted equipment.

3.03 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.04 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Perform inspections as required to obtain a UL Master Label for system.
2. Perform inspections to obtain an LPI certification.

B. Prepare test and inspection reports and certificates.

END OF SECTION

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SECTION 264313
SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

C. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.02 SUMMARY

A. Section includes:

1. Type 2 surge protective devices.
2. Enclosures.
3. Conductors and cables.

B. Related Requirements:

1. Section 262416 "Panelboards"

1.03 DEFINITIONS

A. Inominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: air 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. Type 1 SPDs: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.

I. Type 2 SPDs: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.

J. VPR: Voltage protection rating.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include electrical characteristics, specialties, and accessories for SPDs.
2. NRTL certification of compliance with UL 1449.
   a. Tested values for VPRs.
   b. Inominal ratings.
   c. MCOV, type designations.
   d. OCPD requirements.
   e. Manufacturer's model number.
   f. System voltage.
   g. Modes of protection.

1.05 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.06 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace SPDs that fail in materials or workmanship within five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 TYPE 2 SURGE PROTECTIVE DEVICES (SPDs)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB (Electrification Products Division).
   2. ASCO.
   3. Eaton.
   4. Liebert; a brand of Vertiv.
   5. Mersen USA.
   6. Schneider Electric USA, Inc.
   7. Siemens Industry, Inc., Energy Management Division.

B. Source Limitations: Obtain devices from single source from single manufacturer.

C. Standards:
   1. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2.
   2. Comply with UL 1283.

D. Product Options:
   1. Include LED indicator lights for power and protection status.
   2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
   3. Include NEMA ICS 5, dry Form C contacts rated at 2 A and 24 V ac for remote monitoring of protection status.
   4. Include surge counter.

E. Performance Criteria:
   1. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.
   2. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 250 kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
   3. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits must not exceed the following:
      a. Line to Neutral: 1200 V for 480Y/277 V.
      b. Line to Ground: 1200 V for 480Y/277 V.
      c. Neutral to Ground: 1200 V for 480Y/277 V.
      d. Line to Line: 2000 V for 480Y/277 V.
   4. SCCR: Equal or exceed 100 kA.
   5. Inominal Rating: 20 kA.

2.02 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 1.

B. Outdoor Enclosures: NEMA 250, Type 3R.

2.03 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1.

B. Provide OCPD and disconnect for installation of SPD in accordance with UL 1449 and manufacturer's written instructions.

C. Install leads between disconnects and SPDs short, straight, twisted, and in accordance with manufacturer's written instructions. Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
   1. Do not splice and extend SPD leads unless specifically permitted by manufacturer.
   2. Do not exceed manufacturer's recommended lead length.
   3. Do not bond neutral and ground.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

3.02 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Compare equipment nameplate data for compliance with Drawings and the Specifications.
   2. Inspect anchorage, alignment, grounding, and clearances.
   3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. SPDs that do not pass tests and inspections will be considered defective.

3.03 DEMONSTRATION

A. Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION

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SECTION 265119
LED INTERIOR LIGHTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Cylinder.
   2. Darkroom fixture.
   3. Downlight
   4. Enclosed, Gasketed
   5. Highbay, linear.
   6. Recessed, linear.
   7. Recessed troffer.
   8. Surface mount, linear.
   9. Suspended, linear.
   10. Suspended, nonlinear.
   11. Wall-mounted linear.
   12. Materials.
   13. Luminaire support.

B. Related Requirements:
   1. Section 260941.13 “Digital-Network Lighting Controls” for manual or programmable control systems with low-voltage control wiring or data communication circuits. automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
   2. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   3. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.03 DEFINITIONS

A. CCT: Correlated color temperature.
B. CRI: Color Rendering Index.
C. Fixture: See "Luminaire."
D. IP: International Protection or Ingress Protection Rating.
E. LED: Light-emitting diode.
F. Lumen: Measured output of lamp and luminaire, or both.
G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Arrange in order of luminaire designation.
   2. Include data on features, accessories, and finishes.
   3. Include physical description and dimensions of luminaires.
   4. Include emergency lighting units, including batteries and chargers.
   5. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
   6. Photometric data and adjustment factors based on laboratory tests IES LM-79 and IES LM-80.

a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

B. Shop Drawings: For nonstandard or custom luminaires.
1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Samples for Initial Selection: For each type of luminaire with custom factory-applied finishes.
1. Include Samples of luminaires and accessories involving color and finish selection.

D. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) 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. Drawings shall show field-measured dimensions to ensure that light fixtures will be correct for the specific application. Contractor is responsible for verifying all dimensions prior to order. Drawings shall show:
1. Luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
4. Structural members to which equipment and or luminaires will be attached.
5. Initial access modules for acoustical tile, including size and locations.
6. Items penetrating finished ceiling, including the following:
a. Other luminaires.
b. Air outlets and inlets.
c. Sprinklers.
d. Access panels.
7. Moldings.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Product Certificates: For each type of luminaire.

D. Product Test Reports: For each type of luminaire, for tests performed by a qualified testing agency.

E. Sample warranty.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.07 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications:
1. Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

2. 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 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.09 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Ambient Temperature: 41 to 104 deg F.

1. Relative Humidity: Zero to 95 percent.

B. Altitude: Sea level to 1000 feet.

C. Where light fixtures are both emergency fixtures and have CCT tuning capability, they must also have UL924 devices.

2.02 LUMINAIRE REQUIREMENTS

A. Basis-of design fixtures are shown on lighting fixture schedule on drawings. Substitutions are allowed provided that they are proven equals in materials, performance, and quality.

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. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

D. Recessed luminaires shall comply with NEMA LE 4.

2.03 CYLINDER – Type “K”

A. Nominal Operating Voltage: 277 V ac.

B. Lamp:

1. Minimum illuminance as scheduled on drawings
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of minimum 80. CCT as specified on drawings.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable through range specified on drawings.
6. Internal driver.
7. Lens Thickness: As specified on drawings.

C. Housings:

1. Painted finish. Custom color as specified by Architect.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes: As specified on drawings.

F. With integral mounting provisions.

2.04 DARKROOM FIXTURE – Type "R"

A. Nominal Operating Voltage: 277 V ac.

B. Lamp:

1. Minimum illuminance as scheduled on drawings
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of minimum 80. CCT as specified on drawings.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable through range specified on drawings.
6. Internal dual drivers for narrow-spectrum 630nm red LED lights and normal white LED lights.

C. Lens: Impact-resistant acrylic.

D. Housing – 24-guage, cold-rolled steel suitable for recess in ceiling grid.

E. Listings:

1. Wet-listed
2. IP65
3. Suitable for biosafety labs rated 1-2
4. Suitable for use in FED-STD-209E/Class 1 (ISO 3) Cleanrooms

2.05 DOWNLIGHT – Type "J"

A. Nominal Operating Voltage: 277 V ac.

B. Lamp:

1. Minimum illuminance as scheduled on drawings
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of minimum 80. CCT as specified on drawings.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable through range specified on drawings.
6. Internal driver.
7. Lens Thickness: As specified on drawings.

2.06 ENCLOSED, GASKETED – Type "H"

A. Nominal Operating Voltage: 277 V ac.

B. Lamp:

1. Minimum illuminance as scheduled on drawings
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of minimum 80. CCT as specified on drawings.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable through range specified on drawings.
6. Internal driver.
7. Lens Thickness and material: As specified on drawings.

C. Ratings:

1. Nema 4X
2. Wet-listed

2.07 HIGHBAY, LINEAR – Type "A"

A. Nominal Operating Voltage: 277 V ac.

B. Lamp:

1. Minimum illuminance as scheduled on drawings
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of minimum 80. CCT as specified on drawings.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable through range specified on drawings.
6. Internal driver.

7. Lens Thickness: As specified on drawings.

C. Housings: As specified on drawings

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes: As specified on drawings.

F. Where individually-addressable control and integral sensors are required by drawings, provide appropriate factory-installed modules with fixtures.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.08 RECESSED, LINEAR – Types “E”, “F”, “G”, and “T”

A. Nominal Operating Voltage: 277 V ac.

B. Lamp:

1. Minimum illuminance as scheduled on drawings
2. Minimum allowable efficacy of 85 lm/W.
3. CRI of minimum 80. CCT as specified on drawings.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable through range specified on drawings.
6. Internal driver, except type “T”, requiring an external driver.
7. Lens Thickness: As specified on drawings.

C. Housings: As specified on drawings.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes: As specified on drawings.

F. Mounting: Refer to drawings for mounting design intent. Provide all mounting hardware required depending on what type of ceiling surface to mount in.

2.09 RECESSED TROFFER – Types “B” and “C”

A. Nominal Operating Voltage: 277 V ac.

B. Lamp:

1. Minimum illuminance as scheduled on drawings
2. Minimum allowable efficacy of 85 lm/W.
3. CRI of minimum 80. CCT as specified on drawings.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable through range specified on drawings.
6. Internal driver, except type “T”, requiring an external driver.
7. Lens Thickness: As specified on drawings.

C. Housings: As specified on drawings.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes: As specified on drawings.

F. Mounting: Refer to drawings for mounting design intent. Provide all mounting hardware required depending on what type of ceiling surface to mount in.

G. Where individually-addressable control is required on drawings, provide relevant modules with fixtures.

2.10 SUSPENDED, LINEAR – Types "D" and "U"

A. Nominal Operating Voltage: 277 V ac.

B. Lamp:
   1. Minimum illuminance as scheduled on drawings
   2. Minimum allowable efficacy of 85 lm/W.
   3. CRI of minimum 80. CCT as specified on drawings.
   4. Rated lamp life of 50,000 hours to L70.
   5. Dimmable through range specified on drawings.
   6. Internal driver.
   7. Lens Thickness: As specified on drawings.

C. Housings: As specified on drawings.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes: As specified on drawings.

F. Standards:
   1. ENERGY STAR certified.
   2. RoHS compliant.

2.11 SUSPENDED, NONLINEAR – Type "L"

A. Nominal Operating Voltage: 277 V ac.

B. Lamp:
   1. Minimum illuminance as scheduled on drawings
   2. Minimum allowable efficacy of 85 lm/W.
   3. CRI of minimum 80. CCT as specified on drawings.
   4. Rated lamp life of 50,000 hours to L70.
   5. Dimmable through range specified on drawings.
   6. Internal driver.
   7. Lens Thickness: As specified on drawings.

C. Housings: As specified on drawings.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes: As specified on drawings.

F. Standards:
   1. ENERGY STAR certified.
   2. RoHS compliant.

2.12 WALL-MOUNTED LINEAR – Type "W"

A. Nominal Operating Voltage: 277 V ac.

B. Lamp:
   1. Minimum illuminance as scheduled on drawings
   2. Minimum allowable efficacy of 85 lm/W.
   3. CRI of minimum 80. CCT as specified on drawings.
   4. Rated lamp life of 50,000 hours to L70.
   5. Dimmable through range specified on drawings.
   6. Internal driver.

7. Lens Thickness: As specified on drawings.

C. Housings: As specified on drawings.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes: As specified on drawings.

F. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.

G. Stem brackets – Provide stem mounting for wall or ceiling, as required by drawings.

2.13 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for sheet steel.

C. Stainless Steel:

1. Manufacturer's standard grade.
2. Manufacturer's standard type, ASTM A240/240M.

D. Galvanized Steel: ASTM A653/A653M.

E. Aluminum: ASTM B209.

2.14 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.15 LUMINAIRE SUPPORT

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage.

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

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

3.02 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.
D. Supports:
   1. Sized and rated for luminaire weight.
   2. Able to maintain luminaire position after cleaning and relamping.
   3. Provide support for luminaire without causing deflection of ceiling or wall.
   4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
E. Flush-Mounted Luminaires:
   1. Secured to outlet box.
   2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
   3. Trim ring flush with finished surface.
F. Wall-Mounted Luminaires:
   1. Attached to structural members in walls.
   2. Do not attach luminaires directly to gypsum board.
G. Suspended Luminaires:
   1. Ceiling Mount:
      a. Two 5/32-inch-diameter aircraft cable supports adjustable to 10 feet in length or as required by application.
   2. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
   3. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
   4. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
   5. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.
H. Ceiling-Grid-Mounted Luminaires:
   1. Secure to any required outlet box.
   2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
   3. Seismic Restraint: Install at least one independent support rod or wire from structure to tab on luminaire. Wire or rod must have breaking strength for luminaire weight with safety factor of 3.
I. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.03 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
   2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.05 STARTUP SERVICE

A. Coordinate with requirements in Section 260941.13 “Digital-Network Lighting Controls”.

3.06 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION

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SECTION 265213
EXIT LIGHTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 260010 "Supplemental Requirements for Electrical" specifies additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

C. Section 260011 "Facility Performance Requirements for Electrical" specifies seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.02 SUMMARY

A. Section Includes:

1. Exit signs.
2. Materials.
3. Luminaire support components.

1.03 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Fixture: See "Luminaire" Paragraph.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.

1. Include data on features, accessories, and finishes.
2. Include physical description of the unit and dimensions.
3. Battery and charger for light units.
4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Product Schedule:

1. For exit signs. Use same designations indicated on Drawings.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.07 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Two year(s) from date of Substantial Completion.

B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Emergency Power Unit Batteries: Five years from date of Substantial Completion. Full warranty shall apply for first year and prorated warranty for the remaining four years.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

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. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and NFPA 101.

2.02 EXIT SIGNS – Types “X” and “X1”

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:
   1. Operating at nominal voltage of 277 V ac.
   2. Lamps for AC Operation:
      a. LEDs; 50,000 hours minimum rated lamp life.

C. Type “X1” shall be wet-listed.

2.03 MATERIALS

A. Metal Parts:
   1. Free of burrs and sharp corners and edges.
   2. Sheet metal components shall be steel unless otherwise indicated.
   3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:
   1. Smooth operating, free of light leakage under operating conditions.
   2. Designed to permit relamping without use of tools.
   3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Housings:
   1. Extruded aluminum housing.
   2. powder coat painted finish.

2.04 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.05 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Support Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

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

3.02 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

E. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

F. Ceiling Grid Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.03 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

END OF SECTION

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SECTION 265619
LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Luminaire-mounted photoelectric relays.
   2. Luminaire types.
   3. Materials.
   4. Finishes.
   5. Luminaire support components.

B. Related Requirements:
   1. Section 260941.13 “Digital-Network Lighting Controls” for lighting relays and contactors.
   2. Section 265613 "Lighting Poles and Standards" for poles and standards used to support exterior lighting equipment.
   3. Section 260010 "Supplemental Requirements for Electrical" specifies additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   4. Section 260011 "Facility Performance Requirements for Electrical" specifies seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.02 DEFINITIONS

A. CCT: Correlated color temperature.
B. CRI: Color rendering index.
C. Fixture: See "Luminaire."
D. IP: International Protection or Ingress Protection Rating.
E. Lumen: Measured output of lamp and luminaire, or both.
F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.
   1. Arrange in order of luminaire designation.
   2. Include data on features, accessories, and finishes.
   3. Include physical description and dimensions of luminaire.
   4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
   5. Photometric data and adjustment factors based on laboratory tests, complying with IES LM-79 and IES LM-80.
      a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
   6. Wiring diagrams for power, control, and signal wiring.
   7. Photoelectric relays.
   8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Shop Drawings: For nonstandard or custom luminaires.
   1. Include plans, elevations, sections, and mounting and attachment details.
   2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminairesto include in operation and maintenance manuals.
   1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
   2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.05 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications:
   1. Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
   2. 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 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

D. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.07 FIELD CONDITIONS

A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.

B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.08 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures, including luminaire support components.
      b. Faulty operation of luminaires and accessories.
      c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
   2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 LUMINAIRE REQUIREMENTS

A. Basis-of design fixtures are shown on lighting fixture schedule on drawings. Substitutions are allowed provided that they are proven equals in materials, performance, and quality.

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. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

D. UL Compliance: Comply with UL 1598 and listed for wet location.

E. CRI of 70. CCT as specified on drawings.

F. L70 lamp life of 50,000 hours.

G. Lamps dimmable from 100 percent to 10 percent of maximum light output.
H. Internal driver.
I. Nominal Operating Voltage: 277 V ac.
J. Source Limitations:
1. Obtain luminaires from single source from a single manufacturer.
2. For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.02 LUMINAIRE TYPES

A. Area and Site – Types “M” and “N”.
1. Mounting: Pole or Wall, as applicable.
2. Luminaire-Mounting Height: as specified on drawings.
3. Distribution: as specified on drawings
4. Diffusers and Globes: as specified on drawings.
5. Housings: as specified on drawings.
B. Canopy – Type “S”:
1. Shape: Square.
2. Dimensions: as specified on drawings.
3. Diffusers and Globes: as specified on drawings
4. Housings: as specified on drawings
C. Decorative Post Top – Type “P”:
1. Mounting: Pole.
2. Luminaire-Mounting Height: as specified on drawings.
3. Distribution: as specified on drawings
4. Diffusers and Globes: as specified on drawings.
5. Housings: as specified on drawings.
D. Recessed Linear – Type “V”
1. Mounting: Wall.
2. Luminaire-Mounting Height: as specified on drawings.
3. Distribution: as specified on drawings
4. Diffusers and Globes: as specified on drawings.
5. Housings: as specified on drawings.
6. Operating Temperature -40 degrees F to 140 degrees F
7. Ratings:
a. IK10
b. 3G
c. Wet-listed
8. Remote driver
9. Include all necessary wiring whips from driver to fixture in distances required by installation intent shown on drawings.
10. Include all necessary mounting hardware in ceiling type shown on drawings.
E. Wall Pack – Type “Q”
1. Mounting: Wall.
2. Luminaire-Mounting Height: as specified on drawings.
3. Distribution: as specified on drawings
4. Diffusers and Globes: as specified on drawings.
5. Housings: as specified on drawings.

2.03 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. 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.

C. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

D. 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.

E. Housings:
   1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
   2. Provide filter/breather for enclosed luminaires.

2.04 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

C. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
   2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
      a. Color:
         1) As selected from manufacturer's standard catalog of colors.

2.05 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

C. Examine walls, roofs, canopy ceilings, and overhang ceilings for suitable conditions where luminaires will be installed.

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

3.02 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
C. Install lamps in each luminaire.
D. Fasten luminaire to structural support.
E. Supports:
    1. Sized and rated for luminaire weight.
    2. Able to maintain luminaire position after cleaning and relamping.
    3. Support luminaires without causing deflection of finished surface.
    4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
F. Wall-Mounted Luminaire Support:
    1. Attached to structural members in walls.
G. Wiring Method: Install cables in raceways. Conceal raceways and cables.
H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated.
I. Coordinate layout and installation of luminaires with other construction.
J. Adjust luminaires that require field adjustment or aiming.
K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533.13 "Conduits for Electrical Systems" for wiring connections and wiring methods.

3.03 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 Section 260533.13 "Conduits for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.04 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.05 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
B. Perform the following tests and inspections:
    1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
C. Luminaire will be considered defective if it does not pass tests and inspections.
D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.06 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires.

3.07 STARTUP SERVICE

A. Coordinate with requirements in Section 260941.13 “Digital-Network Lighting Controls”.

3.08 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
    1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.

2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of Architect.

END OF SECTION

SECTION 284621.11
ADDRESSABLE FIRE-ALARM SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Addressable fire-alarm system.
   2. Fire-alarm control unit (FACU).
   3. Manual fire-alarm boxes.
   4. System smoke detectors.
   5. Duct smoke detectors.
   6. Heat detectors.
   7. Multicriteria and multisensor fire detectors.
   8. Fire-alarm notification appliances.
   9. Fire-alarm remote annunciators.
   10. Emergency responder radio coverage system.
   11. Firefighters' two-way telephone communication service.
   12. Digital alarm communicator transmitters (DACTs).

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" specifies additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" specifies seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
   3. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" or Section 260523 "Control Voltage Electrical Power Cables" for cables and conductors for fire-alarm systems.

1.03 DEFINITIONS

A. DACT: Digital alarm communicator transmitter.

B. EMT: Electrical metallic tubing.

C. FACU: Fire-alarm control unit.

D. Mode: The terms "Active Mode," "Off Mode," and "Standby Mode" are used as defined in the 2007 Energy Independence and Security Act (EISA).

E. NICET: National Institute for Certification in Engineering Technologies.

F. PC: Personal computer.

G. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:
   1. Control Voltage: Listed and labeled for use in remote-control, signaling, and power-limited circuits supplied by a Class 2 or Class 3 power supply having rated output not greater than 150 V and 5 A, allowing use of alternate wiring methods complying with NFPA 70, Article 725.
   2. Low Voltage: Listed and labeled for use in circuits supplied by a Class 1 or other power supply having rated output not greater than 1000 V, requiring use of wiring methods complying with NFPA 70, Article 300, Part I.

1.04 ACTION SUBMITTALS

A. Approved Permit Submittal: Submittals must be approved by authorities having jurisdiction prior to submitting them to Architect.

B. Product Data: For each type of product, including furnished options and accessories.
   1. Include construction details, material descriptions, dimensions, profiles, and finishes.
   2. Include rated capacities, operating characteristics, and electrical characteristics.

C. Shop Drawings: For fire-alarm system.
   1. Comply with recommendations and requirements in "Documentation" section of "Fundamentals" chapter in NFPA 72.
   2. Include plans, elevations, sections, and details, including details of attachments to other Work.
   3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
   4. Annunciator panel details as required by authorities having jurisdiction.
   5. Detail assembly and support requirements.
   6. Include voltage drop calculations for notification-appliance circuits.
   7. Include sound pressure calculations. Note that Machines in the CNC lab emit approximately 75 dB each. In the Fabrication lab, there are several stations where angle grinders are used continuously.
   8. Include battery-size calculations.
   9. Include input/output matrix.
   10. Include written statement from manufacturer that equipment and components have been tested as a system and comply with requirements in this Section and in NFPA 72.
   11. Include performance parameters and installation details for each detector.
   12. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
   13. Provide program report showing that air-sampling detector pipe layout balances pneumatically within airflow range of air-sampling detector.
   14. Provide control wiring diagrams for fire-alarm interface to HVAC; coordinate location of duct smoke detectors and access to them.
      a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
      b. Show field wiring and equipment required for HVAC unit shutdown on alarm.
      c. Locate detectors in accordance with manufacturer's written instructions.
   15. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.
   16. Provide UL Fire Alarm System Certificate for submission to DEB.

1.05 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Qualification Statements: For Installer.

C. Sample Warranty: Submittal must include line item pricing for replacement parts and labor.

D. Certificates:

1. Seismic Performance Certificates: For FACU, accessories, and components, from manufacturer. Include the following information:

    a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
    c. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:
    a. Comply with "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
    b. Provide "Fire-Alarm and Emergency Communications System Record of Completion Documents" in accordance with "Completion Documents" Article in "Documentation" section of "Fundamentals" chapter in NFPA 72.
    c. Complete wiring diagrams showing connections between devices and equipment. Each conductor must be numbered at every junction point with indication of origination and termination points.
    d. Riser diagram.
    e. Device addresses.
    f. Record copy of site-specific software.
    g. Provide "Inspection and Testing Form" in accordance with "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
        1) Equipment tested.
        2) Frequency of testing of installed components.
        3) Frequency of inspection of installed components.
        4) Requirements and recommendations related to results of maintenance.
        5) Manufacturer's user training manuals.
    h. Manufacturer's required maintenance related to system warranty requirements.
    i. Abbreviated operating instructions for mounting at FACU and each annunciator unit.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Material: Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
5. Keys and Tools: One extra set for access to locked or tamperproofed components.
6. Audible and Visual Notification Appliances: One of each type installed.

7. Fuses: Two of each type installed in system. Provide in box or cabinet with compartments marked with fuse types and sizes.

1.08 QUALITY ASSURANCE

A. Installer Qualifications:
1. Personnel must be trained and certified by manufacturer for installation of units required for this Project.
2. Installation must be by personnel certified by NICET as fire-alarm Level II technician.
3. Obtain certification by NRTL in accordance with NFPA 72.
4. Licensed or certified by authorities having jurisdiction.

1.09 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail because of defects in materials or workmanship within specified warranty period.
1. Warranty Period: Five years from date of Substantial Completion.

1.10 FIELD CONDITIONS

A. Seismic Conditions: Unless otherwise indicated on Contract Documents, specified Work in this Section must withstand the seismic hazard design loads determined in accordance with ASCE/SEI 7 for installed elevation above or below grade.

1. The term "withstand" means "unit must remain in place without separation of parts from unit when subjected to specified seismic design loads and unit must be fully operational after seismic event."
2.

PART 2 - PRODUCTS

2.01 ADDRESSABLE FIRE-ALARM SYSTEM

A. Description:
1. Noncoded, UL-certified addressable system, with multiplexed signal transmission and horn-and-strobe notification for evacuation.

B. Performance Criteria:
1. Regulatory Requirements:
a. Fire-Alarm Components, Devices, and Accessories: Listed and labeled by a NRTL in accordance with NFPA 70 for use with selected fire-alarm system and marked for intended location and application.
2. General Characteristics:
a. Automatic sensitivity control of certain smoke detectors.
b. Fire-alarm signal initiation must be by one or more of the following devices:
1) Manual stations.
2) Heat detectors.
3) Smoke detectors.
4) Duct smoke detectors
5) Combustible gas detectors.
6) Automatic sprinkler system water flow.
c. Fire-alarm signal must initiate the following actions:
1) Continuously operate alarm notification appliances.
2) Identify alarm and specific initiating device at FACU and remote annunciators.
3) Transmit alarm signal to remote alarm receiving station.

4) Unlock electric door locks in designated egress paths.
5) Release fire and smoke doors held open by magnetic door holders.
6) Switch HVAC equipment controls to fire-alarm mode.
7) Close smoke dampers in air ducts of designated air-conditioning duct systems.
8) Recall elevators to primary or alternate recall floors.
9) Activate elevator power shunt trip.
10) Activate emergency lighting control.
11) Activate emergency shutoffs for gas and fuel supplies.
12) Record events in system memory.
13) Record events by system printer.
14) Indicate device in alarm on graphic annunciator.

d. Supervisory signal initiation must be by one or more of the following devices and actions:
1) Valve supervisory switch.
2) Post Indicator Valve Closed
3) Elevator shunt-trip supervision.
4) Independent fire-detection and -suppression systems.
5) Zones or individual devices have been disabled.
6) FACU has lost communication with network.

e. System trouble signal initiation must be by one or more of the following devices and actions:
1) Open circuits, shorts, and grounds in designated circuits.
2) Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3) Loss of communication with addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4) Loss of primary power at FACU.
5) Ground or single break in internal circuits of FACU.
6) Abnormal ac voltage at FACU.
7) Break in standby battery circuitry.
8) Failure of battery charging.

f. System Supervisory Signal Actions:
1) Initiate notification appliances.
2) Identify specific device initiating event at FACU and remote annunciators.
3) Record event on system printer.
4) After time delay of 200 seconds, transmit trouble or supervisory signal to remote alarm receiving station.
5) Transmit system status to building management system.
6) Display system status on graphic annunciator.

g. Network Communications:
1) Provide network communications for fire-alarm system in accordance with fire-alarm manufacturer's written instructions.
2) Provide network communications pathway per manufacturer's written instructions and requirements in NFPA 72 and NFPA 70.
3) Provide integration gateway using BACnet for connection to building automation system.

h. System Printer:
1) Printer must be listed and labeled as integral part of fire-alarm system.

i. Device Guards:
1) Description: Welded wire mesh of size and shape for manual station, smoke detector, gong, or other device requiring protection.
a) Factory fabricated and furnished by device manufacturer.
b) Finish: Paint of color to match protected device.

j. Document Storage Box:
1) Description: Enclosure to accommodate standard 8-1/2-by-11 inch manuals and loose document records. Legend sheet will be permanently attached to door for system required documentation, key contacts, and system information. Provide two key ring holders with location to mount standard business cards for key contact personnel.
2) Material and Finish: 18-gauge cold-rolled steel; four mounting holes.
3) Color: Red powder-coat epoxy finish.
4) Labeling: Permanently screened with 1 inch high lettering "SYSTEM RECORD DOCUMENTS" with white indelible ink.
5) Security: Locked with 3/4 inch barrel lock. Provide solid 12 inch stainless steel piano hinge.

2.02 FIRE-ALARM CONTROL UNIT (FACU)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bosch Security Systems, Inc.
2. Honeywell International (Honeywell Gamewell-FCI).
3. Honeywell International (Notifier).
4. Honeywell International (Silent Knight).
5. Mircom Technologies, Ltd.
6. Siemens Industry, Inc. (Building Technologies Division).
7. Tyco International (Johnson Controls - SimplexGrinnell).

B. Description: Field-programmable, microprocessor-based, modular, power-limited design with electronic modules.

C. Performance Criteria:
1. Regulatory Requirements: Comply with NFPA 72 and UL 864.
2. Input power: 277 VAC, single-phase.
3. General Characteristics:
a. System software and programs must be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining information through failure of primary and secondary power supplies.
b. Include real-time clock for time annotation of events on event recorder and printer.
c. Provide communication between FACU and remote circuit interface panels, annunciators, and displays.
d. FACU must be listed for connection to central-station signaling system service.
e. Provide nonvolatile memory for system database, logic, and operating system and event history. System must require no manual input to initialize in the event of complete power down condition. FACU must provide minimum 500-event history log.
f. Addressable Initiation Device Circuits: FACU must indicate which communication zones have been silenced and must provide selective silencing of alarm notification appliance by building communication zone.
1) Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: FACU must be listed for releasing service.

g. Fire-Alarm Annunciator: Arranged for interface between human operator at FACU and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.
   1) Annunciator and Display: LCD, 80 characters, minimum.
   2) Keypad: Arranged to permit entry and execution of programming, display, and control commands.

h. Alphanumeric Display and System Controls: Arranged for interface between human operator at FACU and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.
   1) Annunciator and Display: LCD, three line(s) of 40 characters, minimum.
   2) Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into system for control of smoke-detector sensitivity and other parameters.

i. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
   1) Pathway Class Designations: NFPA 72, Class B.
   2) Install no more than 256 addressable devices on each signaling-line circuit.
   3) Install fault circuit isolators to comply with circuit performance requirements of NFPA 72 or with manufacturer's written instructions, whichever is more conservative.

j. Serial Interfaces:
   1) One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
   2) One USB port for PC configuration.

k. Smoke-Alarm Verification:
   1) Initiate audible and visible indication of "alarm-verification" signal at FACU.
   2) Activate approved "alarm-verification" sequence at FACU and detector.
   3) Record events by system printer.
   4) Sound general alarm if alarm is verified.
   5) Cancel FACU indication and system reset if alarm is not verified.

l. Notification-Appliance Circuit:
   1) Audible appliances must sound in three-pulse temporal pattern, as defined in NFPA 72.
   2) Notification appliances must provide an alarm signal that is a 520 Hz square wave with intensity 15 dB above average ambient sound level or at least 75 dB(A-weighted), whichever is greater. In the tenant manufacturing spaces (111, 120, 122, 125, 128), assume an ambient sound level of 84 dB.
   3) Visual alarm appliances must flash in synchronization where multiple appliances are in same field of view, as defined in NFPA 72.

m. Elevator Recall: Initiate by one of the following alarm-initiating devices:
   1) Elevator lobby detectors except lobby detector on designated floor.
   2) Smoke detectors in elevator hoistway.

n. Elevator controller must be programmed to move cars to alternate recall floor if lobby detectors located on designated recall floors are activated.

o. Water-flow alarm connected to sprinkler in elevator shaft and elevator machine room must shut down elevators associated with location without time delay.
   1) Water-flow switch associated with sprinkler in elevator pit may have delay to allow elevators to move to designated floor.

p. Remote Smoke-Detector Sensitivity Adjustment: Controls must select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out final adjusted values on system printer.

q. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to remote alarm station.

r. Status Annunciator: Indicate status of various voice/alarm speaker zones and status of firefighters' two-way telephone communication zones.

s. Preamplifiers, amplifiers, and tone generators must automatically transfer to backup units, on primary equipment failure.

t. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from other printed indications. Also, print system reset event, including same information for device, location, date, and time. Commands initiate printing of list of existing alarm, supervisory, and trouble conditions in system and historical log of events.

u. Primary Power: 24 V(dc) obtained from 277 V(ac) service and power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, and must be powered by 24 V(dc) source.

v. Alarm current draw of entire fire-alarm system must not exceed 80 percent of power-supply module rating.

w. Secondary Power: 24 V(dc) supply system with batteries, automatic battery charger, and automatic transfer switch. Batteries shall be sized to the capacity requirements of NFPA 72 10.6.7.

x. Batteries: Sealed lead calcium.

D. Accessories:

1. Instructions: Computer printout or typewritten instruction card mounted behind plastic or glass cover in stainless steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe functional operation of system under normal, alarm, and trouble conditions.

2.03 MANUAL FIRE-ALARM BOXES

A. Provide by same manufacturer as Fire Alarm Control Unit.

B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes must be finished in red with molded, raised-letter operating instructions in contrasting color; must show visible indication of operation; and must be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Single-action mechanism, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to FACU.
2. Station Reset: Key- or wrench-operated switch.
3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at top to permit lifting for access to initiate alarm. Lifting cover actuates integral battery-powered audible horn intended to discourage false-alarm operation.
4. Able to perform at up to 90 percent relative humidity at 90 deg F.
5. Material: Manual stations made of Lexan polycarbonate.
6. Able to be used in indoor areas.

2.04 SYSTEM SMOKE DETECTORS

A. Photoelectric Smoke Detectors:
   1. Provide by same manufacturer as Fire Alarm control unit.
   2. Performance Criteria:
      a. Regulatory Requirements:
         1) NFPA 72.
         2) UL 268.
      b. General Characteristics:
         1) Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
         2) Base Mounting: Detector and associated electronic components must be mounted in twist-lock module that connects to fixed base. Provide terminals in fixed base for connection to building wiring.
         3) Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
         4) Integral Visual-Indicating Light: LED type, indicating detector has operated.
         5) Detector address must be accessible from FACU and must be able to identify detector's location within system and its sensitivity setting.
         6) Operator at FACU, having designated access level, must be able to manually access the following for each detector:
            a) Primary status.
            b) Device type.
            c) Present average value.
            d) Present sensitivity selected.
            e) Sensor range (normal, dirty, etc.).
         7) Detector must have functional humidity range within 10 to 90 percent relative humidity.
         8) Color: White, unless otherwise indicated. Some locations require black smoke detectors. These locations are called out on drawings.
         9) Remote Control: Unless otherwise indicated, detectors must be digital-addressable type, individually monitored at FACU for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by FACU.
         10) Rate-of-rise temperature characteristic of combination smoke- and heat-detection units must be selectable at FACU for 15 or 20 deg F per minute.
         11) Multiple levels of detection sensitivity for each sensor.

2.05 DUCT SMOKE DETECTORS

A. Provide by same manufacturer as Fire Alarm Control Unit.
B. Description: Photoelectric-type, duct-mounted smoke detector.
C. Performance Criteria:
   1. Regulatory Requirements:
      a. NFPA 72.
      b. UL 268A.
   2. General Characteristics:
      a. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
      b. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
      c. Integral Visual-Indicating Light: LED type, indicating detector has operated.

d. Detector address must be accessible from FACU and must be able to identify detector's location within system and its sensitivity setting.
e. Operator at FACU, having designated access level, must be able to manually access the following for each detector:
   1) Primary status.
   2) Device type.
   3) Present average value.
   4) Present sensitivity selected.
   5) Sensor range (normal, dirty, etc.).
f. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with supplied detector for smoke detection in HVAC system ducts.
g. Each sensor must have multiple levels of detection sensitivity.
h. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
i. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.06 HEAT DETECTORS

A. Combination-Type Heat Detectors:
   1. Provide from same manufacturer as Fire Alarm Control Unit.
   2. Performance Criteria:
      a. Regulatory Requirements:
         1) NFPA 72.
         2) UL 521.
      b. General Characteristics:
         1) Temperature sensors must test for and communicate sensitivity range of device.
      c. Actuated by fixed temperature of 135 deg F or rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
      d. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
      e. Detector must have functional humidity range of 10 to 90 percent relative humidity.
      f. Color: White.

2.07 MULTICRITERIA AND MULTISENSOR FIRE DETECTORS

A. Multiple devices shown in the same location bay be combined into a single device, if not prohibited by code.

2.08 FIRE-ALARM NOTIFICATION APPLIANCES

A. Fire-Alarm Audible Notification Appliances:
   1. Provide from same manufacturer as Fire Alarm Control Unit.
   2. Description: Horns, bells, or other notification devices that cannot output voice messages.
   3. Performance Criteria:
      a. Regulatory Requirements:
         1) NFPA 72.
      b. General Characteristics:
         1) Individually addressed, connected to signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.
         2) Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

3) Horns: Electric-vibrating-polarized type, 24 V(dc); with provision for housing operating mechanism behind grille. Comply with UL 464. Horns must produce sound-pressure level of 90 dB(A-weighted), measured 10 ft. from horn, using coded signal prescribed in UL 464 test protocol.
4) Combination Devices: Factory-integrated audible and visible devices in single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

B. Fire-Alarm Visible Notification Appliances:
1. Provide from same manufacturer as Fire Alarm Control Unit.
2. Performance Criteria:
a. Regulatory Requirements:
1) NFPA 72.
2) UL 1971.
b. General Characteristics:
1) Rated Light Output as noted on drawings.
2) Clear or nominal white polycarbonate lens mounted on aluminum faceplate.
3) Mounting: Wall mounted unless otherwise indicated.
4) For units with guards to prevent physical damage, light output ratings must be determined with guards in place.
5) Flashing must be in temporal pattern, synchronized with other units.
6) Strobe Leads: Factory connected to screw terminals.
7) Mounting Faceplate: Factory finished, white.

2.09 FIREFIGHTERS' TWO-WAY TELEPHONE COMMUNICATION SERVICE

A. Provide from same manufacturer as Fire Alarm Control Unit.
B. Description: Dedicated, two-way, supervised, telephone voice communication links between FACU and remote firefighters' telephone stations. Supervised telephone lines must be connected to talk circuits by controls in control module.
C. Performance Criteria:
1. Regulatory Requirements:
a. NFPA 72.
2. General Characteristics:
a. Selective-talk type for use by firefighters.
b. Controls to disconnect phones from talk circuits if too many phones are in use simultaneously. Indicator lamp must flash if phone is disconnected from talk circuits.
c. Addressable firefighters' phone modules to monitor and control loop of firefighter phones. Module must be capable of differentiating between normal, off-hook, and trouble conditions.
d. Audible Pulse and Tone Generator, and High-Intensity Lamp: When remote telephone is taken off hook, it causes audible signal to sound and high-intensity lamp to flash at FACU.
e. Selector panel controls to provide for simultaneous operation of up to six telephones in selected zones. Indicate ground faults and open or shorted telephone lines on panel front by individual LEDs.
f. Display: Digital to indicate location of caller.
g. Remote Telephone Cabinet: Flush- or surface-mounted cabinet as indicated; factory-standard red finish; with handset.

1) Install one-piece handset to cabinet with vandal-resistant armored cord. Silk-screened or engraved label on cabinet door, designating "Fire Emergency Phone."
2) With "break-glass" door access lock.

h. Remote Telephone Jack Stations: Single-gang, stainless steel-plate mounted plug, engraved "Fire Emergency Phone."

i. Handsets: push-to-talk sets with noise-canceling microphone stored in cabinet.

2.10 EMERGENCY RESPONDER RADIO COVERAGE SYSTEM

A. Provide from same manufacturer as Fire Alarm Control Unit.

B. Description: Emergency responder radio coverage systems use a combination of bidirectional amplifiers and distributed antenna systems to boost signals for sustaining two-way radio communications throughout a facility, including stairwells, underground tunnels, parking garages, and other challenging areas.

C. Performance Criteria:

1. Regulatory Requirements:
   a. In accordance with NFPA 72, emergency responder radio coverage systems must be designed, installed, and maintained in accordance with NFPA 1221.
2. General Characteristics:
   a. Where emergency responder radio coverage system is used in lieu of two-way in-building wired emergency communications system, it must have pathway survivability of Level 4 as defined in NFPA 72 12.4.
   b. Where leaky feeder cable is used as antenna, it must neither be required to be installed in metal raceway nor meet survivability requirements.
   c. Feeder and riser coaxial cables must be rated as plenum cables.
   d. Feeder coaxial cables must be connected to riser coaxial cables using hybrid coupler devices of value determined by overall design.
   e. Where emergency responder radio coverage system is used in lieu of two-way in-building wired emergency communications system, design of system must be approved by authorities having jurisdiction. Riser coaxial cables must be rated as riser cables and routed through 2-hour-rated enclosure.
   f. Connection between riser and feeder coaxial cables must be made within 2-hour-rated enclosure, and passage of feeder cable in and out of 2-hour-rated enclosure must be firestopped to 2-hour ratings.

2.11 FIRE-ALARM REMOTE ANNUNCIATORS

A. Provide from same manufacturer as Fire Alarm Control Unit.

B. Performance Criteria:

1. Regulatory Requirements:
   a. NFPA 72.
2. General Characteristics:
   a. Annunciator functions must match those of FACU for alarm, supervisory, and trouble indications. Manual switching functions must match those of FACU, including acknowledging, silencing, resetting, and testing.
      1) Mounting: Flush cabinet, NEMA 250, Type 1.
   b. Display Type and Functional Performance: Alphanumeric display and LED indicating lights must match those of FACU. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.12 FIRE-ALARM ADDRESSABLE INTERFACE DEVICES

A. Provide from same manufacturer as Fire Alarm Control Unit.

B. Performance Criteria:

1. Regulatory Requirements:
   a. NFPA 72.
2. General Characteristics:
   a. Include address-setting means on module.
   b. Store internal identifying code for control panel use to identify module type.
   c. Listed for controlling HVAC fan motor controllers.
   d. Monitor Module: Microelectronic module providing system address for alarm-initiating devices for wired applications with normally open contacts.
   e. Integral Relay: Capable of providing direct signal to elevator controller to initiate elevator recall to circuit-breaker shunt trip for power shutdown.
      1) Allow control panel to switch relay contacts on command.
      2) Have minimum of two normally open and two normally closed contacts available for field wiring.
   f. Control Module:
      1) Operate notification devices.
      2) Operate solenoids for use in sprinkler service.

2.13 DIGITAL ALARM COMMUNICATOR TRANSMITTERS (DACTs)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Bosch Security Systems, Inc.
   2. Potter Electric Signal Company, LLC.
   3. United Technologies Corporation (UTC Climate, Controls & Security - Edwards).

B. Performance Criteria:
   1. Regulatory Requirements:
      a. NFPA 72.
   2. General Characteristics:
      a. DACT must be acceptable to remote central station and must be listed for fire-alarm use.
      b. Functional Performance: Unit must receive alarm, supervisory, or trouble signal from FACU and automatically capture two telephone lines and a secondary internet communication interface and dial preset number for remote central station. DACT must also have the capability of cellular connection. Coordinate with Owner on which call-out methods are preferred. When contact is made with central station(s), signals must be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter must initiate local trouble signal and transmit signal indicating loss of telephone line to remote alarm receiving station over remaining line. Transmitter must automatically report telephone service restoration to central station. If service is lost on both telephone lines, transmitter must initiate local trouble signal.
      c. Local functions and display at DACT must include the following:
         1) Verification that both lines are available.
         2) Programming device.
         3) LED display.
         4) Manual test report function and manual transmission clear indication.
         5) Communications failure with central station or FACU.
      d. Digital data transmission must include the following:
         1) Address of alarm-initiating device.
         2) Address of supervisory signal.
         3) Address of trouble-initiating device.

4) Loss of ac supply.
5) Loss of power.
6) Low battery.
7) Abnormal test signal.
8) Communication bus failure.

e. Secondary Power: Integral rechargeable battery and automatic charger.
f. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are 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.

3.02 PREPARATION

A. Protection of In-Place Conditions: Protect devices during construction unless devices are placed in service to protect facility during construction.

3.03 INSTALLATION OF EQUIPMENT

A. Comply with NECA 305, NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."
1. Devices placed in service before other trades have completed cleanup must be replaced.
2. Devices installed, but not yet placed, in service must be protected from construction dust, debris, dirt, moisture, and damage in accordance with manufacturer's written storage instructions.
B. Install seismic bracing. Comply with requirements in Section 260548 "Seismic Controls for Electircal Systems."
C. Install wall-mounted equipment, with tops of cabinets not more than 78 inch above finished floor.
D. Manual Fire-Alarm Boxes:
1. Install manual fire-alarm box in normal path of egress within 60 inch of exit doorway.
2. Mount manual fire-alarm box on background of contrasting color.
3. Operable part of manual fire-alarm box must be between 42 and 48 inch above floor level. Devices must be mounted at same height unless otherwise indicated.
E. Smoke- and Heat-Detector Spacing:
1. Comply with "Smoke-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with "Heat-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing must not exceed 30 ft..
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas must be determined in accordance with Annex Ain NFPA 72.

5. HVAC: Locate detectors not closer than 36 inch from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inch from lighting fixture and not directly above pendant mounted or indirect lighting.

F. Install cover on each smoke detector that is not placed in service during construction. Cover must remain in place except during system testing. Remove cover prior to system turnover.

G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend full width of duct. Tubes more than 36 inch long must be supported at both ends.
1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

H. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

I. Remote Status and Alarm Indicators: Install in visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

J. Audible Alarm-Indicating Devices: Install not less than 6 inch below ceiling. Install bells and horns on flush-mounted back boxes with device-operating mechanism concealed behind grille. Install devices at same height unless otherwise indicated.

K. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inch below ceiling. Install devices at same height unless otherwise indicated.

3.04 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
1. Nameplate must be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate must be laminated acrylic or melamine plastic signs with black background and engraved white letters at least 1/2 inch high.

3.05 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.06 PATHWAYS

A. Pathways above recessed ceilings and in inaccessible locations may be routed exposed.

B. Exposed pathways must be installed in EMT.

C. Exposed EMT must be painted red enamel.

3.07 CONNECTIONS

A. Make addressable connections with supervised interface device to the following devices and systems. Install interface device less than 36 inch from device controlled. Make

addressable confirmation connection when such feedback is available at device or system being controlled.

1. Alarm-initiating connection to elevator recall system and components.
2. Alarm-initiating connection to activate emergency lighting control.
3. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
4. Supervisory connections at valve supervisory switches.
5. Supervisory connections at elevator shunt-trip breaker.
6. Data communication circuits for connection to building management system.
7. Data communication circuits for connection to mass notification system.

3.08 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

B. Install framed instructions in location visible from FACU.

C. Post a copy of the UL Fire Alarm System Certificate within 3 feet of the FACU.

3.09 GROUNDING

A. Ground FACU and associated circuits in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Ground shielded cables at control panel location only. Insulate shield at device location.

3.10 FIELD QUALITY CONTROL

A. Administrant for Tests and Inspections:

1. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.
   a. Inspection must be based on completed record Drawings and system documentation that is required by "Completion Documents, Preparation" table in "Documentation" section of "Fundamentals" chapter in NFPA 72.
   b. Comply with "Visual Inspection Frequencies" table in "Inspection" section of "Inspection, Testing and Maintenance" chapter in NFPA 72; retain "Initial/Reacceptance" column and list only installed components.
2. System Testing: Comply with "Test Methods" table in "Testing" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for public operating mode in accordance with manufacturer's written instructions. Perform test using portable sound-level meter complying with Type 2 requirements in ASA S1.4 Part 1/IEC 61672-1.
4. Test audible appliances for private operating mode in accordance with manufacturer's written instructions.
5. Test visible appliances for public operating mode in accordance with manufacturer's written instructions.
6. Factory-authorized service representative must prepare "Fire Alarm System Record of Completion" in "Documentation" section of "Fundamentals" chapter in NFPA 72 and "Inspection and Testing Form" in "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.

C. Reacceptance Testing: Perform reacceptance testing to verify proper operation of added or replaced devices and appliances.

D. Fire-alarm system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

G. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.11 MAINTENANCE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service must include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies must be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections in accordance with "Visual Inspection Frequencies" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in "Test Methods" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per "Testing Frequencies" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.

END OF SECTION

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SECTION 311000 - SITE CLEARING

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:

1. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing above- and below-grade site improvements.
6. Disconnecting, capping or sealing, and removing site utilities.
7. Temporary erosion- and sedimentation-control measures.

1.3 DEFINITIONS

A. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

B. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow.

D. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.

E. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.

F. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and indicated on Drawings.

G. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.4 MATERIAL OWNERSHIP

A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 SUBMITTALS

A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.

1. Use sufficiently detailed photographs or videotape.
2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plants designated to remain.

B. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.6 QUALITY ASSURANCE

A. Preinstallation Conference: Conduct conference at Project site.

1.7 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.

1. Do not proceed with work on adjoining property until directed by Architect/Engineer.

C. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.

D. Utility Locator Service: Notify Miss Utility for area where Project is located before site clearing.

E. Do not commence site clearing operations until temporary erosion- and sedimentation-control measures are in place.

F. The following practices are prohibited within protection zones:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Foot traffic.
4. Erection of sheds or structures.
5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.
7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

G. Do not direct vehicle or equipment exhaust towards protection zones.

H. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

I. Soil Stripping, Handling, and Stockpiling: Perform only when the topsoil is dry or slightly moist.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Division 31 Section "Earth Moving."

1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly identify trees, shrubs, and other vegetation to remain. Flag each tree trunk at 54 inches above the ground.

C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

A. General: Protect trees and plants remaining on-site.

B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by Architect/Engineer.

3.4 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches below exposed subgrade.
3. Use only hand methods for grubbing within protection zones.
4. Chip removed tree branches and dispose of off-site.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.5 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to depth of 6 inches in a manner to prevent intermingling with underlying subsoil or other waste materials.

1. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects more than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

1. Limit height of topsoil stockpiles to 72 inches.
2. Do not stockpile topsoil within protection zones.

3. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.
4. Stockpile surplus topsoil to allow for respreading deeper topsoil.

3.6 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
2. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

3.7 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Refer to Specification Section 017419 “Construction Waste Management and Disposal.”

B. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

C. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 311000

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SECTION 312000 - EARTH MOVING

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:

1. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses, and plants.
2. Excavating and backfilling for buildings and structures.
3. Drainage course for concrete slabs-on-grade.
4. Subbase course for concrete walks.
5. Subbase course and base course for asphalt paving.
6. Subsurface drainage backfill for walls and trenches.
7. Excavating and backfilling trenches for utilities and pits for buried utility structures.

1.3 UNIT PRICES

A. Work of this Section is affected by unit prices for earth moving as noted on the bid form.

B. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed the following. Unit prices for rock excavation include replacement with approved materials.

1. 24 inches outside of concrete forms other than at footings.
2. 12 inches outside of concrete forms at footings.
3. 6 inches outside of minimum required dimensions of concrete cast against grade.
4. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
5. 6 inches beneath bottom of concrete slabs-on-grade.
6. 6 inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

1.4 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
2. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.
3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by owner's geotechnical engineer. Unauthorized excavation, as well as remedial work directed by the owner's geotechnical engineer, shall be without additional compensation.

G. Fill: Soil materials used to raise existing grades.

H. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material 3/4 cu. yd. or more in volume that exceed a standard penetration resistance of 100 blows/2 inches when tested by a geotechnical testing agency, according to ASTM D 1586.

I. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

J. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

K. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

L. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.5 SUBMITTALS

A. Product Data: For each type of the following manufactured products required:

1. Geotextiles.
2. Controlled low-strength material, including design mixture.
3. Geofoam.

4. Warning tapes.

B. Samples for Verification: For the following products, in sizes indicated below:

1. Geotextile: 12 by 12 inches.
2. Warning Tape: 12 inches long; of each color.

C. Qualification Data: For qualified testing agency.

D. Test Reports: All soil test reports required under field quality control shall be performed by an independent agency approved and paid for by the Owner. The independent laboratory shall perform all soil tests including the following:

1. Laboratory analysis of each soil material proposed for fill and backfill from on-site and borrow sources.
1. One optimum moisture-maximum density curve for each soil material.
2. Report of actual unconfined compressive strength and/or results of bearing tests of each stratum tested.

D. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by earth moving operations. Submit before earth moving begins.

E. Erosion Prevention Plan: Prior commencement of work under this section of the specification, the contractor shall implement the erosion prevention plan detailed in the contract documents. After implementation of the erosion prevention plan, the contractor shall be held responsible for the strict adherence thereto.

F. Existing Utilities: Locate all existing underground utilities in areas of work. Perform all required tests including test pits to accurately locate all existing underground utilities prior to any excavations or sheeting and shoring design. Document and record location of all existing underground utilities in the work area for future use and Owner's record. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations. Support shall be designed by a licensed professional engineer and approved by the Architect/Engineer. Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by the Owner and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify the Owner not less than ten days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without the Owner's written permission. The Owner will coordinate the interruption of service with the Contractor and all parties affected.
3. Contractor requests for outages shall include an identification of areas that will be affected by proposed outage.

1.6 QUALITY ASSURANCE

A. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.

B. Preexcavation Conference: Conduct conference at Project site.

1.7 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Do not commence earth moving operations until temporary erosion- and sedimentation-control measures, are in place.

C. The following practices are prohibited within protection zones:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Foot traffic.
4. Erection of sheds or structures.
5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.
7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

D. Do not direct vehicle or equipment exhaust towards protection zones.

E. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: ASTM D 2487 soil classification groups GW, GP, SW, SP, SM, SC, ML, MH, and CL; free of rock or gravel larger than 2 inches in any dimension, debris, waste, frozen materials, vegetation and other deleterious matter. Any deviations from these material specifications shall be approved by the Geotechnical Engineer.

C. Unsatisfactory Soils: ASTM D 2487 soil classification groups GC, CH, OL, OH, and PT. Any deviations from these material specifications shall be approved by the Geotechnical Engineer.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95 percent passing a 1-1/2-inch sieve and not more than 8 percent passing a No. 200 sieve.

F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.

H. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.

I. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and 0 to 5 percent passing a No. 4 sieve.

J. Sand: ASTM C 33; fine aggregate.

K. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 GEOTEXTILES

A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Survivability: Class 2; AASHTO M 288.
2. Grab Tensile Strength: 157 lbf; ASTM D 4632.
3. Sewn Seam Strength: 142 lbf ; ASTM D 4632.
4. Tear Strength: 56 lbf ; ASTM D 4533.
5. Puncture Strength: 56 lbf ; ASTM D 4833.

2.3 ACCESSORIES

A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility and a printed caption in black letters “CAUTION-

BURIED DISTRIBUTION PIPING BELOW" or similar wording with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep. Above all pipe installations install a #10 wire with both ends terminated in a manhole or junction box.

B. Tape Colors: Provide tape colors to utilities as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.

B. Protect and maintain erosion and sedimentation controls during earth moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

3.3 EXPLOSIVES

A. Explosives: The use of explosives is not permitted.

3.4 EXCAVATION, GENERAL

A. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by the owner's testing and inspection firm. The Contract Sum will be adjusted for

rock excavation according to unit prices included on the Bid Form. Changes in the Contract Time may be authorized for rock excavation.

1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; together with soil, boulders, and other materials not classified as rock or unauthorized excavation.

    a. Intermittent drilling; ram hammering; or ripping of material not classified as rock excavation is earth excavation.

2. Rock excavation includes removal and disposal of rock. Remove rock to lines and subgrade elevations indicated to permit installation of permanent construction without exceeding the following dimensions:

    a. 24 inches outside of concrete forms other than at footings.
    b. 12 inches outside of concrete forms at footings.
    c. 6 inches outside of minimum required dimensions of concrete cast against grade.
    d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
    e. 6 inches beneath bottom of concrete slabs-on-grade.
    f. 6 inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
2. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended as bearing surfaces.

B. Excavations at Edges of Tree- and Plant-Protection Zones:

1. Excavate by hand to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Cut and protect roots as required.

C. Where rock is encountered, notify the Engineer. When the entire structure will bear on rock, it shall be used to support the foundation. Where only a part of the foundation will bear on rock, excavate 8 inches below subgrade of floor or footing, backfill with aggregate fill and thoroughly compact.

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.

1. Clearance: 12 inches each side of pipe or conduit.

C. Trench Bottoms: Excavate trenches 4 inches deeper than bottom of pipe and conduit elevations to allow for bedding course. Shape subgrade to provide continuous support for bells, joints and barrels of pipes and for joints, fittings and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade. Hand-excavate deeper for bells of pipe.

1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

D. Trenches in Tree- and Plant-Protection Zones:

1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.

3.8 SUBGRADE INSPECTION

A. Notify the owner’s geotechnical engineer when excavations have reached required subgrade.

B. If the owner’s geotechnical engineer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by the owner’s geotechnical engineer, and replace with compacted backfill or fill as directed.

D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.

E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by the owner's geotechnical engineer, without additional compensation.

3.9 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi, may be used when approved by the owner's geotechnical engineer and building's structural engineer.

1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

3.10 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.11 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.12 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings.

D. Trenches under Roadways: Provide 4-inch thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase course.

E. Backfill voids with satisfactory soil while removing shoring and bracing.

F. Place and compact initial backfill of subbase material, satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

G. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of 12 inches over the pipe or conduit. Coordinate backfilling with utilities testing.

H. Place and compact final backfill of satisfactory soil to final subgrade elevation.

I. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.

J. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.13 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:

1. Under grass and planted areas, use satisfactory soil material.
2. Under walks and pavements, use satisfactory soil material.
3. Under steps and ramps, use satisfactory soil material.
4. Under building slabs, use satisfactory soil material.
5. Under footings and foundations, use satisfactory soil material.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.14 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.

2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Refer to the project Geotechnical Engineering Report for structural fill placement requirements.

3.16 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Turf or Unpaved Areas: Plus or minus 1 inch
2. Walks: Plus or minus 1 inch.
3. Pavements: Plus or minus 1/2 inch.

C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch (when tested with a 10-foot straightedge.

3.17 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place subbase course and base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place subbase course and base course under pavements and walks as follows:

1. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
2. Place base course material over subbase course under hot-mix asphalt pavement.
3. Shape subbase course and base course to required crown elevations and cross-slope grades.
4. Place subbase course and base course 6 inches or less in compacted thickness in a single layer.
5. Place subbase course and base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
6. Compact subbase course and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.18 EROSION CONTROL

A. Permanent or temporary soil stabilization shall be applied to denuded areas within 7 days after final grade is reached on any portion of the site. Soil stabilization shall also be applied within 7 days to denuded areas which may not be at final grade but will remain dormant (undisturbed) for longer than 14 days. Soil stabilization practices included vegetative establishment, mulching and the early application of gravel base on areas to be paved.

3.19 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:

1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
2. Determine that fill material and maximum lift thickness comply with requirements.
3. Determine, at the required frequency, that in-place density of compacted fill complies with requirements.

B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.

E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:

1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area or building slab, but in no case fewer than three tests.
2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length, but no fewer than two tests.
3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests.

F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.20 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 312000

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SECTION 321216 - ASPHALT PAVING

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:

1. Cold milling of existing hot-mix asphalt pavement.
2. Hot-mix asphalt patching.
3. Hot-mix asphalt paving.
4. Hot-mix asphalt paving overlay.
5. Pavement-marking paint.

B. Related Sections:

1. Division 31 Section “Earth Moving” for aggregate subbase and base courses and for aggregate pavement shoulders.

1.3 DEFINITION

A. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 for definitions of terms.

1.4 SUBMITTALS

A. Material Certificates: Provide copies of materials certificates signed by material producer and contractor, certifying that each material item complies with, or exceeds, specified requirements.

B. Shop Drawings: Indicate pavement markings, lane separations, and defined parking spaces. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

1.5 QUALITY ASSURANCE

A. Codes and Standards: Comply with the publications of the following agencies to the extent referenced and applicable:

1. AASHTO “American Association of State Highway Transportation Officials”
2. ASTM “American Society of Testing and Materials”
3. OSHA “Occupational Safety and Health Act”
4. VDOT “Virginia Department of Transportation Road and Bridge Specifications”

B. Manufacturer Qualifications: Engage a firm experienced in manufacturing hot-mix asphalt similar to that indicated for this Project and with a record of successful in-service performance.

C. Installer Qualifications: Engage an experienced installer who has completed hot-mix asphalt paving similar in material design, and extent to that indicated for this Project and with a record of successful in-service performance.

D. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

E. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:

a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
b. Review condition of subgrade and preparatory work.
c. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
d. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.

B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:

1. Prime Coat: Minimum surface temperature of 60 deg F.
2. Tack Coat: Minimum surface temperature of 60 deg F .
3. Slurry Coat: Comply with weather limitations in ASTM D 3910.
4. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
5. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.

B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for oil-based materials, and not exceeding 95 deg F .

C. Grade Control: Establish and maintain required lines and elevations. Avoid ponding of drainage.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Use locally available materials and gradations which exhibit a satisfactory record of previous installations.

B. Base Course Aggregate: In accordance with Virginia Department of Transportation Road and Bridge Specifications Section 309.

C. Surface Course Aggregate: In accordance with Virginia Department of Transportation Road and Bridge Specifications Section 313.

D. Tack Coat: In accordance with Virginia Department of Transportation Road and Bridge Specifications Section 310.

E. Prime Coat: In accordance with Virginia Department of Transportation Road and Bridge Specifications Section 311.

F. Lane Marking Paint: In accordance with Virginia Department of Transportation Road and Bridge Specifications Section 704.

2.2 ASPHALT- AGGREGATE MIXTURE

A. Provide plant-mixed, hot-laid asphalt-aggregate mixture complying with ASTM D 3515 and Virginia Department of Transportation Road and Bridge Specifications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

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

D. Verify that utilities, traffic loop detectors, and other items requiring a cut and installation beneath the asphalt surface have been completed and that asphalt surface has been repaired flush with adjacent asphalt prior to beginning installation of imprinted asphalt.

3.2 PAVEMENT REMOVAL

A. General: Make a straight line saw cut 12 inches beyond the edge of the excavation to a minimum depth of 2 inches for bituminous concrete pavement.

3.3 PATCHING

A. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of 0.2 gal./sq. yd..

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.4 SUBGRADE PREPARATION

A. General: See specification Section 312000, “Earth Moving”.

B. Establishment of Grades: Establish grades and set grade stakes, make due allowances for existing improvements, proper drainage, and adjoining property rights. No gradient shall be less than one percent, unless otherwise indicated.

C. Subgrade for Driveways and Parking: Compaction shall be to at least 95 percent of maximum density at optimum moisture content. Remove spongy and unsuitable material to depth necessary to achieve density and replace with approved material. Loosen exceptionally hard surfaces, and recompact for uniform bearing power. Maintain subgrades and properly drain until paved.

D. Herbicide Treatment: Apply chemical weed control agent in strict compliance with manufacturer’s recommended dosages and application instructions. Apply to compacted dry subbase prior to application of prime coat.

3.5 REPAIRS

A. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than 1 inch in existing pavements.

1. Install leveling wedges in compacted lifts not exceeding 3 inches thick.

B. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of 1/4 inch.

1. Clean cracks and joints in existing hot-mix asphalt pavement.
2. Use emulsified-asphalt slurry to seal cracks and joints less than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.
3. Use hot-applied joint sealant to seal cracks and joints more than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.

3.6 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at rate specified on plans. Apply enough material to penetrate and seal but not flood surface. Allow prime coat to cure.

1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
2. Protect primed substrate from damage until ready to receive paving.

C. Tack Coat: Apply uniformly to surfaces of existing pavement at rate specified on plans.

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.7 HOT-MIX ASPHALT PLACEMENT

A. In accordance with Virginia Department of Transportation Road and Bridge Specifications Section 315.

3.8 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

B. Allow paving to age for 30 days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Thickness: In accordance with Virginia Department of Transportation Road and Bridge Specifications Section 315.

C. Surface Smoothness: In accordance with Virginia Department of Transportation Road and Bridge Specifications Section 315.

D. In-Place Density: In accordance with Virginia Department of Transportation Road and Bridge Specifications Section 315

E. Replace and compact hot-mix asphalt where core tests were taken.

F. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.10 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.

1. Do not allow milled materials to accumulate on-site.

3.11 PROTECTION

A. Protection of Pavement: Sections of newly finished pavement shall be protected from traffic until they have become properly hardened. Erect barricades to protect pouring from traffic until mixture has cooled enough not to become marked.

END OF SECTION 321216

SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Curbs and gutters.
2. Walks.

1.03 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color selection.

C. Other Action Submittals:

1. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.05 INFORMATIONAL SUBMITTALS

A. Material Certificates: For the following, from manufacturer:

1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Fiber reinforcement.
4. Admixtures.
5. Curing compounds.
6. Applied finish materials.
7. Bonding agent or epoxy adhesive.
8. Joint fillers.

B. Field quality-control reports.

1.06 QUALITY ASSURANCE

A. Detectable Warning Installer Qualifications: An employer of workers trained and approved by manufacturer of stamped concrete paving systems.

B. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

C. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

D. Concrete Testing Service: Engage a qualified testing agency to perform material evaluation tests and to design concrete mixtures.

E. ACI Publications: Comply with ACI 301 unless otherwise indicated.

1.07 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 - PRODUCTS

2.01 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.02 STEEL REINFORCEMENT

A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Plain-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, fabricated from as-drawn steel wire into flat sheets.

C. Deformed-Steel Welded Wire Reinforcement: ASTM A 497/A 497M, flat sheet.

D. Epoxy-Coated Welded Wire Reinforcement: ASTM A 884/A 884M, Class A, plain steel.

E. Reinforcing Bars: ASTM A 615/A 615M, Grade 60; deformed.

F. Galvanized Reinforcing Bars: ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized after fabrication and bending; with ASTM A 615/A 615M, Grade 60 deformed bars.

G. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M; with ASTM A 615/A 615M, Grade 60 deformed bars.

H. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60, deformed bars; assembled with clips.

I. Plain-Steel Wire: ASTM A 82/A 82M, as drawn.

J. Deformed-Steel Wire: ASTM A 496/A 496M.

K. Epoxy-Coated-Steel Wire: ASTM A 884/A 884M, Class A coated, plain.

L. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 plain-steel bars. Cut bars true to length with ends square and free of burrs.

M. Epoxy-Coated, Joint Dowel Bars: ASTM A 775/A 775M; with ASTM A 615/A 615M, Grade 60, plain-steel bars.

N. Tie Bars: ASTM A 615/A 615M, Grade 60, deformed.

O. Hook Bolts: ASTM A 307, Grade A, internally and externally threaded. Design hook-bolt joint assembly to hold coupling against paving form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.

P. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.

Q. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating, compatible with epoxy coating on reinforcement.

R. Zinc Repair Material: ASTM A 780.

2.03 CONCRETE MATERIALS

A. Cementitious Material: Use one of the following cementitious materials, of the same type, brand, and source throughout the Project:

1. Portland Cement: ASTM C 150, Type I or III, gray.

a. Fly Ash: ASTM C 618, Class C or F.
b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

2. Blended Hydraulic Cement: ASTM C 595, Type IP, portland-pozzolan cement.

B. Normal-Weight Aggregates: ASTM C 33, Class 4S, 4M, 1N, coarse aggregate, uniformly graded. Provide aggregates from a single source[with documented service record data of at least 10 years' satisfactory service in similar pavement applications and service conditions using similar aggregates and cementitious materials].

1. Maximum Coarse-Aggregate Size: 1-1/2 inches nominal.
2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Exposed Aggregate: Selected, hard, and durable; washed; free of materials with deleterious reactivity to cement or that cause staining; from a single source, with gap-graded coarse aggregate as follows:

1. Aggregate Sizes: 3/4 to 1 inch nominal.

D. Water: ASTM C 94/C 94M.

E. Air-Entraining Admixture: ASTM C 260.

F. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

2.04 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) dry.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.

1. Products:

a. Axim Concrete Technologies; Cimfilm.
b. Burke by Edeco; BurkeFilm.
c. ChemMasters; Spray-Film.
d. Conspec Marketing & Manufacturing Co., Inc.; Aquafilm.
e. Dayton Superior Corporation; Sure Film.
f. Euclid Chemical Company (The); Eucobar.
g. Kaufman Products, Inc.; Vapor Aid.

h. Lambert Corporation; Lambco Skin.
i. L&M Construction Chemicals, Inc.; E-Con.
j. MBT Protection and Repair, ChemRex Inc.; Confilm.
k. Meadows, W. R., Inc.; Sealtight Evapre.
l. Metalcrete Industries; Waterhold.
m. Nox-Crete Products Group, Kinsman Corporation; Monofilm.
n. Sika Corporation, Inc.; SikaFilm.
o. Symons Corporation; Finishing Aid.
p. Vexcon Chemicals, Inc.; Certi-Vex EnvioAssist.

E. Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.

1. Products:

a. Anti-Hydro International, Inc.; AH Curing Compound #2 DR WB.
b. Burke by Edoko; Aqua Resin Cure.
c. ChemMasters; Safe-Cure Clear.
d. Conspec Marketing & Manufacturing Co., Inc.; W.B. Resin Cure.
e. Dayton Superior Corporation; Day Chem Rez Cure (J-11-W).
f. Euclid Chemical Company (The); Kurez DR VOX.
g. Kaufman Products, Inc.; Thinfilm 420.
h. Lambert Corporation; Aqua Kure-Clear.
i. L&M Construction Chemicals, Inc.; L&M Cure R.
j. Meadows, W. R., Inc.; 1100 Clear.
k. Nox-Crete Products Group, Kinsman Corporation; Resin Cure E.
l. Symons Corporation; Resi-Chem Clear.
m. Tamms Industries Inc.; Horncure WB 30.
n. Unitex; Hydro Cure 309.
o. Vexcon Chemicals, Inc.; Certi-Vex Enviocure 100.

F. White Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B.

1. Products:

a. Anti-Hydro International, Inc.; AH Curing Compound #2 WP WB.
b. Burke by Edoco; Resin Emulsion White.
c. ChemMasters; Safe-Cure 2000.
d. Conspec Marketing & Manufacturing Co., Inc.; W.B. Resin Cure.
e. Dayton Superior Corporation; Day-Chem White Pigmented Cure (J-10-W).
f. Euclid Chemical Company (The); Kurez VOX White Pigmented.
g. Kaufman Products, Inc.; Thinfilm 450.
h. Lambert Corporation; Aqua Kure-White.
i. L&M Construction Chemicals, Inc.; L&M Cure R-2.
j. Meadows, W. R., Inc.; 1200-White.
k. Symons Corporation; Resi-Chem White.
l. Tamms Industries, Inc.; Horncure 200-W.
m. Unitex; Hydro White.
n. Vexcon Chemicals, Inc.; Certi-Vex Enviocure White 100.

2.05 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber or ASTM D 1752, cork or self-expanding cork.

B. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, free of carbon black, nonfading, and resistant to lime and other alkalis.

1. Manufacturers:

a. Bayer Corporation.
b. ChemMasters.
c. Conspec Marketing & Manufacturing Co., Inc.
d. Davis Colors.
e. Elementis Pigments, Inc.
f. Hoover Color Corporation.
g. Lambert Corporation.
h. Scofield, L. M.Company.
i. Solomon Colors.

2. Color: As selected by Architect from manufacturer's full range.

C. Slip-Resistive Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of fused aluminum-oxide granules or crushed emery with emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials.

D. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

E. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to requirements, and as follows:

1. Types I and II, non-load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

F. Chemical Surface Retarder: Water-soluble, liquid-set retarder with color dye, for horizontal concrete surface application, capable of temporarily delaying final hardening of concrete to a depth of 1/8 to 1/4 inch (3 to 6 mm).

1. Products:

a. Burke by Edeco; True Etch Surface Retarder.
b. ChemMasters; Exposee.
c. Conspec Marketing & Manufacturing Co., Inc.; Delay S.
d. Euclid Chemical Company (The); Surface Retarder S.
e. Kaufman Products, Inc.; Expose.
f. Metalcrete Industries; Surftard.
g. Nox-Crete Products Group, Kinsman Corporation; Crete-Nox TA.
h. Scofield, L. M. Company; Lithotex.

i. Sika Corporation, Inc.; Rugasol-S.
j. Vexcon Chemicals, Inc.; Certi-Vex Envioset.

G. Pigmented Mineral Dry-Shake Hardener: Factory-packaged dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.

1. Products:

a. Conspec Marketing & Manufacturing Co., Inc.; Conshake 600 Colortone.
b. Dayton Superior Corporation; Quartz Tuff.
c. Euclid Chemical Company (The); Surflex.
d. Lambert Corporation; Colorhard.
e. L&M Construction Chemicals, Inc.; Quartz Plate FF.
f. MBT Protection and Repair, ChemRex Inc.; Mastercron.
g. Metalcrete Industries; Floor Quartz.
h. Scofield, L. M. Company; Lithochrome Color Hardener.
i. Symons Corporation; Hard Top.

2. Color: As selected by Architect from manufacturer's full range.

2.06 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mixes or field experience.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete mixture designs for the trial batch method.

B. Proportion mixtures to provide normal-weight concrete with the following properties:

1. Compressive Strength (28 Days): 3000 psi.
2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.50.
3. Slump Limit: 4 inches (100 mm) plus or minus 1 inch (25 mm).

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:

1. Air Content: 5-1/2 percent plus or minus 1.5 percent for 1-1/2-inch (38-mm) nominal maximum aggregate size.

D. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water-reducing admixture plasticizing and retarding admixture in concrete, as required, for placement and workability.
2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

F. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements for concrete exposed to deicing chemicals.

G. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

2.07 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M and ASTM C 1116. Furnish batch certificates for each batch discharged and used in the Work.

1. When air temperature is between 85 deg F (30 deg C) and 90 deg F (32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For concrete mixes of 1 cu. yd. (0.76 cu. m) or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
2. For concrete mixes larger than 1 cu. yd. (0.76 cu. m), increase mixing time by 15 seconds for each additional 1 cu. yd. (0.76 cu. m).
3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared subbase surface below concrete pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding.

1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph.
2. Proof-roll with a loaded 10-wheel tandem-axle dump truck weighing not less than 15 tons.
3. Subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch require correction according to requirements in Division 31 Section "Earth Moving."

C. Proceed with concrete pavement operations only after nonconforming conditions have been corrected and subgrade is ready to receive pavement.

3.02 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.03 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.04 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

D. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

E. Zinc-Coated Reinforcement: Use galvanized-steel wire ties to fasten zinc-coated reinforcement. Repair cut and damaged zinc coatings with zinc repair material.

F. Epoxy-Coated Reinforcement: Use epoxy-coated steel wire ties to fasten epoxy-coated reinforcement. Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D 3963/D 3963M.

G. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch overlap of adjacent mats.

3.05 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline, unless otherwise indicated.

1. When joining existing pavement, place transverse joints to align with previously placed joints, unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour unless pavement terminates at isolation joints.

1. Continue steel reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of pavement strips, unless otherwise indicated.
2. Provide tie bars at sides of pavement strips where indicated.
3. Butt Joints: Use bonding agent at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

4. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys, unless otherwise indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete.
5. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt-coat one-half of dowel length to prevent concrete bonding to one side of joint.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.

1. Locate expansion joints at intervals of 50 feet, unless otherwise indicated.
2. Extend joint fillers full width and depth of joint.
3. Terminate joint filler not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) below finished surface if joint sealant is indicated.
4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
6. Protect top edge of joint filler during concrete placement with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows to match jointing of existing adjacent concrete pavement:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.
2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch-wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
3. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding to one side of joint.

E. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.

3.06 CONCRETE PLACEMENT

A. Inspection: Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast in. Notify other trades to permit installation of their work.

B. Remove snow, ice, or frost from subbase surface and reinforcement before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site.

F. Do not add water to fresh concrete after testing.

G. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

H. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.

I. Place concrete in two operations; strike off initial pour for entire width of placement and to the required depth below finish surface. Lay welded wire fabric or fabricated bar mats immediately in final position. Place top layer of concrete, strike off, and screed.

1. Remove and replace concrete that has been placed for more than 15 minutes without being covered by top layer, or use bonding agent if approved by Architect.

J. Screed pavement surfaces with a straightedge and strike off.

K. Commence initial floating using bull floats or darbies to impart an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

L. Curbs and Gutters: When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing as specified for formed concrete. If results are not approved, remove and replace with formed concrete.

M. Slip-Form Pavers: When automatic machine placement is used for pavement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce pavement to required thickness, lines, grades, finish, and jointing as required for formed pavement.

1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of paver machine during operations.

N. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.

O. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
2. Do not use frozen materials or materials containing ice or snow.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mix designs.

P. Hot-Weather Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.07 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
2. Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.
3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch deep with a stiff-bristled broom, perpendicular to line of traffic.

3.08 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:

1. Moist Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

a. Water.
b. Continuous water-fog spray.
c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.09 PAVING TOLERANCES

A. Comply with tolerances of ACI 117 and as follows:

1. Elevation: 1/4 inch (6 mm).
2. Thickness: Plus 3/8 inch (10 mm), minus 1/4 inch (6 mm).
3. Surface: Gap below 10-foot- (3-m-) long, unleveled straightedge not to exceed 1/4 inch (6 mm).
4. Lateral Alignment and Spacing of Tie Bars and Dowels: 1 inch (25 mm).
5. Vertical Alignment of Tie Bars and Dowels: 1/4 inch (6 mm).
6. Alignment of Tie-Bar End Relative to Line Perpendicular to Pavement Edge: 1/2 inch (13 mm).
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Pavement Edge: Length of dowel 1/4 inch per 12 inches (6 mm per 300 mm).
8. Joint Spacing: 3 inches (75 mm).
9. Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.
10. Joint Width: Plus 1/8 inch (3 mm), no minus.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least 1 composite sample for each 100 cu. yd. or fraction thereof of each concrete mix placed each day.

a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
4. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when 80 deg F (27 deg C) and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C 39/C 39M; test 1 specimen at 7 days and 2 specimens at 28 days.

a. A compressive-strength test shall be the average compressive strength from 2 specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mix will be satisfactory if average of any 3 consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

G. Remove and replace concrete pavement where test results indicate that it does not comply with specified requirements.

H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.11 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION

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SECTION 323100
ORNAMENTAL CANTILEVER GATE SYSTEM

PART 1 - GENERAL

1.01 REFERENCE STANDARDS

A. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2023.

B. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus; 2019.

C. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes; 2021.

D. ASTM D523 - Standard Test Method for Specular Gloss; 2014 (Reapproved 2018).

E. ASTM D714 - Standard Test Method for Evaluating Degree of Blistering of Paints; 2002 (Reapproved 2017).

F. ASTM D1654 - Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments; 2008, with Editorial Revision (2017).

G. ASTM D2244 - Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates; 2023.

H. ASTM D2794 - Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact); 1993 (Reapproved 2024).

I. ASTM D3359 - Standard Test Methods for Rating Adhesion by Tape Test; 2023.

J. ASTM F2200 - Standard Specification for Automated Vehicular Gate Construction; 2020.

K. UL 325 - Standard for Door, Drapery, Gate, Louver, and Window Operators and Systems; Current Edition, Including All Revisions.

1.02 SECTION INCLUDES

A. Ornamental cantilever gate system.

1.03 RELATED SECTIONS

A. Section 033000 - Cast-In-Place Concrete

B. Section 312000 - Earthwork

1.04 SYSTEM DESCRIPTION

A. The manufacturer shall supply a total ornamental cantilever gate system including all components (i.e., tracks, uprights, bracing, pickets, safety equipment, hardware and fasteners) required.

B. Coordinate access controls with Owner’s access control vendor. Provide related hardware not otherwise provided by the access control vendor such as control pedestal.

1.05 QUALITY ASSURANCE

A. The contractor shall provide laborers and supervisors who are thoroughly familiar with the type of construction involved and materials and techniques specified.

1.06 REFERENCES

A. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.

B. ASTM B117 - Practice for Operating Salt-Spray (Fog) Apparatus.

C. ASTM B221 – Aluminum and Aluminum Alloy Extruded Bars, Shapes and Tubes

D. ASTM D523 - Test Method for Specular Gloss.

E. ASTM D714 - Test Method for Evaluating Degree of Blistering in Paint.

F. ASTM D822 - Practice for Conducting Tests on Paint and Related Coatings and Materials using Filtered Open-Flame Carbon-Arc Light and Water Exposure Apparatus.

G. ASTM D1654 - Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments.

H. ASTM D2244 - Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates.

I. ASTM D2794 - Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).

J. ASTM D3359 - Test Method for Measuring Adhesion by Tape Test.

1.07 SUBMITTAL

A. The manufacturer's submittal package shall be provided prior to installation.

B. Product Data: For each gate, operator, and controllers.

C. Shop Drawings: Include plans, elevations, sections, details, attachment to and clearances from other work.

1.08 PRODUCT HANDLING AND STORAGE

A. Upon receipt at the job site, all materials shall be checked to ensure that no damages occurred during shipping or handling. Materials shall be stored in such a manner to ensure proper ventilation and drainage, and to protect against damage, weather, vandalism and theft.

PART 2 - MATERIALS

2.01 MANUFACTURER

A. Basis of Design - Ameristar TransPort Traverse II gate system, Majestic design, manufactured by Ameristar Perimeter Security USA Inc., in Tulsa, Oklahoma.

2.02 MATERIAL

A. The materials used for cantilever gate framing (uprights & diagonal bracing) shall be manufactured from ASTM A653 Steel with yield strength of 34,800 PSI, a tensile strength of 37,700PSI and a standard mill finish. The aluminum extrusions for top and bottom enclosed tracks shall be alloy and temper designation 6005-T5 to meet ASTM B221.

B. Material for pickets shall be 1” square x 16 ga. steel pickets on gate systems less than 22’ openings, gate systems greater than 22’ openings shall have 1" square x 1/8” wall aluminum pickets. Picket on center spacing shall not exceed 5". Pickets shall be securely fastened to face of top and bottom enclosed track extrusions.

C. Material for gate uprights shall be 2 ½” X 16 ga. and diagonal bracing shall be 2” square x 16 ga. steel. The cross-sectional shape of the enclosed-track shall confirm to the manufacturers design with a single extrusion consisting of a 3.75” x 7” channeled support with integrated 3” x 3” enclosed-track raceway. Gates less than 18-foot openings shall be constructed as a single-track system, gates greater than 20-foot openings shall be constructed as a spliced track system.

D. Steel material for fence posts and pickets shall be galvanized prior to forming in accordance with the requirements of ASTM A653/A653M, with minimum yield strength of 45,000 psi (310264.20 kPa). The steel shall be hot-dip galvanized to meet the requirements of ASTM A653/A653M with a minimum zinc coating weight of 0.90 oz/ft2 (276 g/m2), Coating Designation G-90. Depending on application and gate size, material for gate support posts shall be 4” x 11 Ga., or 6” x 3/16”.

E. Support carriage trolly assemblies, for the gates enclosed bottom track, shall have two mounting options: concrete slab or post mount bracket configuration, and shall support the vertical load of the gate. The gates center of gravity shall be centered on the bottom support carriage trolly assemblies. Installation of the carriage trolly assemblies shall be per manufacturer’s installation instructions (written or video).

F. Finish: Powder coat finish with a minimum thickness of 2 mils (0.0508 mm)
   1. Shall be selected from the manufacturer's full line of colors and finishes by the Architect.

2.03 FABRICATION

A. Gate frame uprights and diagonal bracing shall be prefabricated and pre-punched to accept frame fasteners. Enclosed track shall be pre-punched to accept gate uprights. Pickets shall be precut to specified length and predrilled to accept picket to track fasteners. Posts shall be precut to specified lengths.

B. Top and bottom enclosed track extrusions shall be mechanically fastened to vertical gate uprights and intermediate supports, as required by assembly instructions. Diagonal bracing shall be mechanically fastened to vertical gate uprights and intermediate supports, as required by assembly instructions. Pickets shall be mechanically fastened to top and bottom enclosed track, as required by assembly instructions.

C. The manufactured gate components shall be subjected to coating process capable of meeting the following performance requirements:
   1. Adhesion – ASTM Test 3359 – Method B
      a. Adhesion (Retention of Coating) over 90% of test area (Tape and knife test).
   2. Corrosion Resistance – ASTM Test B117, D714 & D1654 chart
      a. Corrosion Resistance over 1,000 hours (Scribed per D1654; failure mode is accumulation of 1/8” coating loss from scribe or medium #8 blisters).
   3. Impact Resistance – ASTM Test D2794

D. Impact Resistance over 60 inch (1524 mm) lb. (Forward impact using 0.625” ball).
   1. Weathering Resistance – ASTM Test D822 D2244, D523 (60˚ Method)
      a. Weathering Resistance over 1,000 hours (Failure mode is 60% loss of gloss or color variance of more than 3 delta-E color units).

PART 3 - EXECUTION

3.01 PREPARATION

A. All new installation shall be laid out by the contractor in accordance with the construction plans.

3.02 GATE INSTALLATION

A. Cantilever support posts shall be set in concrete footers having a minimum depth of 48” (Note: In most cases, local soil, code restrictions and inclement weather conditions may require a greater depth). Posts shall be spaced according to gate specific submittal drawings. Safety Kit must be included if the gate is automated. The “Earthwork” and “Concrete” sections of this specification shall govern material requirements for the concrete footer.

B. Gate to be installed per manufacturers gate installation instructions. For gates that will be automated, the contractor shall be responsible to ensure the gate, and installation, meet ASTM F2200 and UL 325 Standards.

3.03 GATE INSTALLATION MAINTENANCE

A. When cutting/drilling posts adhere to the following steps to seal the exposed steel surfaces:
   1. Remove all metal shavings from cut area.
   2. Apply zinc-rich primer to thoroughly cover cut edge and/or drilled hole; let dry.
   3. Apply 2 coats of custom finish paint matching fence color. Failure to seal exposed surfaces per steps 1-3 above will negate warranty. Ameristar spray cans or paint pens shall be used to prime and finish exposed surfaces; it is recommended that paint pens be used to prevent overspray. Use of non-Ameristar parts or components will negate the manufactures’ warranty.

3.04 GATE INSTALLATION

A. Gate posts shall be spaced according to the manufacturers’ drawings, dependent on clear opening. The manufacturers’ gate drawings shall identify the necessary gate hardware required for the application. Gate hardware shall be provided by the manufacture of the gate and shall be installed per manufacturer’s recommendations.

3.05 CLEANING

A. The contractor shall clean the jobsite of excess materials; post-hole excavations shall be scattered uniformly away from posts.

END OF SECTION

SECTION 323111
GATE OPERATORS - LIFTMASTER

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Sliding gate operators.

1.02 RELATED REQUIREMENTS

A. Section 033000 - Cast-in-Place Concrete.

B. Section 323100 - Ornamental Cantilever Gate System

C. Section 323113 - Chain Link Fences and Gates.

1.03 REFERENCE STANDARDS

A. ASTM F2200 - Standard Specification for Automated Vehicular Gate Construction; 2020.

B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2020.

C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

D. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.

E. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.

F. UL 325 - Standard for Door, Drapery, Gate, Louver, and Window Operators and Systems; Current Edition, Including All Revisions.

1.04 SUBMITTALS

A. See Section 013000 - Administrative Requirements for submittal procedures.

B. Product Data: Indicated data on operators.

C. Field Quality Control Submittals: Field inspections.

D. Manufacturer's qualification statement.

E. Gate operator installer's qualification statement.

F. Executed warranty.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with minimum 3 years of documented experience.

B. Gate Operator Installer Qualifications: Company with demonstrated successful experience installing similar projects and products, with minimum 3 years of documented experience.

1.06 WARRANTY

A. See Section 017800 - Closeout Submittals for additional warranty requirements.

B. Manufacturer Warranty: Provide 2-year manufacturer warranty for gate operator. Complete forms in Owner's name and register with manufacturer.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. LiftMaster: www.liftmaster.com/#sle.

B. Substitutions: See Section 016000 - Product Requirements.

2.02 MATERIALS

A. Sliding Gate Operators: Pre-wired, gate-mounted gate operator for horizontal sliding gates in accordance with ASTM F2200 and 2.

1. Operating Type: Roller chain.
2. Maximum Gate Weight: 1,000 lb (454 kg).
3. Horsepower Rating: Suitable for connected load.
4. Control Functions: Open, pause, and close.
5. Maximum Open/Close Time: 12 to 15 seconds.
6. Access: Execute with card, keypad, loop detector, and remote.
7. Entrapment Protection Devices: Provide sensing devices and safety mechanisms complying with UL 325.
8. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
9. Battery Backup: 12 V.
10. Solar Charging: 10 W.
11. Products: LiftMaster; CSL24UL.

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide concrete center drop to footing depth and drop rod retainers at center of double gate openings.

B. Install gate locking device; see Section 323113.

C. Peen bolts upon installation.

D. Install operator, battery, and solar panels in accordance with manufacturer's instructions and in accordance with NFPA 70.

3.02 FIELD QUALITY CONTROL

A. See Section 014000 - Quality Requirements for additional requirements.

B. Operators: Inspect for level, plumb, and alignment.

C. Perform three random field inspections confirming installation.

3.03 CLOSEOUT ACTIVITIES

A. Demonstrate operation of equipment to Owner's designated representative.

3.04 MAINTENANCE

A. See Section 017000 - Execution and Closeout Requirements for additional requirements.

B. Provide separate maintenance contract for service and maintenance for three years from Date of Substantial Completion.

END OF SECTION

SECTION 323113
CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Posts, rails, and frames.

B. Wire fabric.

C. Manual gates with related hardware.

D. Accessories.

1.02 RELATED REQUIREMENTS

A. Section 033000 - Cast-in-Place Concrete: Concrete anchorage for posts.

1.03 REFERENCE STANDARDS

A. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2023.

B. ASTM A392 - Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric; 2011a (Reapproved 2022).

C. ASTM F567 - Standard Practice for Installation of Chain-Link Fence; 2023.

D. CLFMI CLF-FIG0111 - Field Inspection Guide; 2014.

E. CLFMI CLF-SFR0111 - Security Fencing Recommendations; 2014.

F. FS RR-F-191/1D - Fencing, Wire and Post Metal (Chain-Link Fence Fabric); 1990.

1.04 SUBMITTALS

A. See Section 013000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide data on fabric, posts, accessories, fittings and hardware.

C. Shop Drawings: Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, and schedule of components. See CLFMI CLF-SFR0111 for planning and design recommendations.

D. Samples: Submit two samples of fence fabric, slat infill, 12 inch (304.8 mm) by 12 inch (304.8 mm) in size illustrating construction and colored finish.

E. Manufacturer's Installation Instructions: Indicate installation requirements, post foundation anchor bolt templates, and _____.

F. Manufacturer's Qualification Statement.

G. Fence Installer Qualification Statement.

H. Project Record Documents: Accurately record actual locations of property perimeter posts relative to property lines.

1.05 QUALITY ASSURANCE

1.06 WARRANTY

A. See Section 017800 - Closeout Submittals, for additional warranty requirements.

B. Correct defective Work within a five year period after Date of Substantial Completion.

C. Provide five year manufacturer warranty for chain link fence and gate systems.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Chain Link Fences and Gates:
   1. Master-Halco, Inc: www.masterhalco.com/#sle.
   2. Merchants Metals: www.merchantsmetals.com/#sle.

3. Substitutions: See Section 016000 - Product Requirements.

2.02 COMPONENTS

A. Line Posts: 1.9 inch (48 mm) diameter.

B. Corner and Terminal Posts: 2.38 inch (60 mm) diameter.

C. Gate Posts: 3-1/2 inch (89 mm) diameter.

D. Top and Brace Rail: 1.66 inch (42 mm) diameter, plain end, sleeve coupled.

E. Bottom Rail: 1.66 inch (42 mm) diameter, plain end, sleeve coupled.

F. Gate Frame: 1.66 inch (42 mm) diameter for welded fabrication.

G. Fabric: 2 inch (51 mm) diamond mesh interwoven wire, 6 gauge, 0.1920 inch (4.9 mm) thick, top selvage knuckle end closed, bottom selvage twisted tight.

H. Tension Wire: 6 gauge, 0.1920 inch (4.9 mm) thick steel, single strand.

I. Tie Wire: Aluminum alloy steel wire.

2.03 MATERIALS

A. Posts, Rails, and Frames:
   1. Line Posts: Type I round in accordance with FS RR-F-191/1D.
   2. Terminal, Corner, Rail, Brace, and Gate Posts: Type I round in accordance with FS RR-F-191/1D.

B. Wire Fabric:
   1. ASTM A392 zinc coated steel chain link fabric.

2.04 MANUAL GATES AND RELATED HARDWARE

A. Hardware for Single Swinging Gates: 180 degree hinges, 2 for gates up to 60 inches (1,525 mm) high, 3 for taller gates; fork latch with gravity drop and padlock hasp; keeper to hold gate in fully open position.

B. Hardware for Double Swinging Gates: 180 degree hinges, 2 for gates up to 60 inches (1,525 mm) high, 3 for taller gates; drop bolt on inactive leaf engaging socket stop set in concrete, active leaf latched to inactive leaf preventing raising of drop bolt, padlock hasp; keepers to hold gate in fully open position.

C. Hinges: Finished to match fence components.

D. Latches: Finished to match fence components.

2.05 ACCESSORIES

A. Caps: Cast steel galvanized; sized to post diameter, set screw retainer.

B. Fittings: Sleeves, bands, clips, rail ends, tension bars, fasteners and fittings; steel.

2.06 FINISHES

A. Components and Fabric: Vinyl coated over coating of 1.8 ounces per square foot galvanizing (over coating of 550 g/sq m galvanizing).

B. Hardware: Hot-dip galvanized to weight required by ASTM A153/A153M.

C. Accessories: Same finish as framing.

D. Color(s): To be selected by Architect from manufacturer's standard range.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Verify that areas are clear of obstructions or debris.

3.02 PREPARATION

A. Removal: Obstructions or debris.

3.03 INSTALLATION

A. Install framework, fabric, accessories and gates in accordance with ASTM F567.

B. Place fabric on outside of posts and rails.

C. Set intermediate, terminal, and gate posts plumb , in concrete footings with top of footing 2 inches (50 mm) above finish grade. Slope top of concrete for water runoff.

D. Line Post Footing Depth Below Finish Grade: ASTM F567.

E. Corner, Gate and Terminal Post Footing Depth Below Finish Grade: ASTM F567.

F. Brace each gate and corner post to adjacent line post with horizontal center brace rail and diagonal truss rods. Install brace rail one bay from end and gate posts.

G. Provide top rail through line post tops and splice with 6 inch (150 mm) long rail sleeves.

H. Stretch fabric between terminal posts or at intervals of 100 feet (30 m) maximum, whichever is less.

I. Position bottom of fabric 2 inches (50 mm) above finished grade.

J. Fasten fabric to top rail, line posts, braces, and bottom tension wire with tie wire at maximum 15 inches (380 mm) on centers.

K. Attach fabric to end, corner, and gate posts with tension bars and tension bar clips.

L. Install bottom tension wire stretched taut between terminal posts.

M. Install hardware and gate with fabric to match fence.

N. Provide concrete center drop to footing depth and drop rod retainers at center of double gate openings.

3.04 TOLERANCES

A. Maximum Variation From Plumb: 1/4 inch (6 mm).

B. Maximum Offset From True Position: 1 inch (25 mm).

C. Do not infringe on adjacent property lines.

3.05 FIELD QUALITY CONTROL

A. See Section 014000 - Quality Requirements, for additional requirements.

B. Layout: Verify that fence installation markings are accurate to design, paying attention to gate locations, underground utilities, and property lines.

C. Fence Height: Randomly measure fence height at three locations or at areas that appear out of compliance with design.

D. Gates: Inspect for level, plumb, and alignment.

E. Workmanship: Verify neat installation free of defects. See CLFMI CLF-FIG0111 for field inspection guidance.

3.06 CLEANING

A. Leave immediate work area neat at end of each work day.

B. Clean jobsite of excess materials; scatter excess material from post hole excavations uniformly away from posts. Remove excess material if required.

C. Clean fence with mild household detergent and clean water rinse well.

D. Touch up scratched surfaces using materials recommended by manufacturer. Match touched-up paint color to factory-applied finish.

3.07 CLOSEOUT ACTIVITIES

A. See Section 017800 - Closeout Submittals, for closeout submittals.

B. Training: Train Owner's personnel on operation and maintenance of system.

1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.

2. Provide minimum of two hours of training.
3. Location: At project site.

END OF SECTION

SECTION 323136
SECURITY GATES AND BARRIERS

PART 1 GENERAL

1.01 SECTION INCLUDES

1.02 RELATED REQUIREMENTS

A. Section 260533.13 - Conduit for Electrical Systems: Empty conduit between system components.

B. Section 260583 - Wiring Connections: Electrical power connections to the hydraulic power unit and controls.

C. Section 312316 - Excavation: Excavating for footings, and utility trenching.

D. Section 321313 - Concrete Paving: Installation of adjacent paved surfaces.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination: Coordinate installation of units with size, location and installation of service utilities.

B. Sequencing: Ensure that utility connections are completed in an orderly and expeditious manner.

1.04 SUBMITTALS

A. See Section 013000 - Administrative Requirements, for submittal procedures.

B. Shop Drawings: Provide detailed drawings showing:
   1. Layout and overall dimensions of each major element of the barrier equipment, including the hydraulic power unit and operator control panels, if applicable.
   2. Electrical schematic including associated wiring, showing electrically connected components, including interface points for connection to equipment; indicate minimum conduit size and number of wires required to run between each component of the barrier equipment.

C. Manufacturer's Qualification Statement.

D. Installer's Qualification Statement.

E. Operation and Maintenance Data.

F. Specimen Warranty.

G. Maintenance Materials: Furnish the following for Owner's use in project maintenance.
   1. See Section 016000 - Product Requirements, for additional provisions.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than five years of documented experience.

B. Installer's Qualifications: Company specializing in performing the work of this section with minimum 3 years of experience.

1.06 DELIVERY, STORAGE AND HANDLING

A. Store materials in a manner to ensure proper ventilation and drainage. Protect against damage, weather, vandalism and theft.

1.07 WARRANTY

A. See Section 017800 - Closeout Submittals, for additional warranty requirements.

B. Correct defective Work within a one year period after Date of Substantial Completion.

C. Provide one year manufacturer warranty for materials and workmanship.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Security Gates and Barriers:
   1. Ameristar Perimeter Security, USA; Echelon II: www.ameristarperimeter.com/#sle.
   2. Substitutions: See Section 016000 - Product Requirements.

2.02 SECURITY GATES AND BARRIERS

A. Security Gates and Barriers: Factory-fabricated, -assembled, and -tested devices, including components for satisfactory operation; capable of resisting specified impact when installed in foundations indicated on drawings.

B. Material: Hot-dipped galvanized steel with painted finish.

C. Color: As selected from manufacturer's standard.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of Conditions:
   1. Verify location of existing utilities, grades and conditions of substrate.
   2. Verify integration requirements with other site security equipment including but not limited to card readers, tire puncture devices, gates and other automated barrier systems.

3.02 PREPARATION

A. Protect existing work from damage due to installation of this work.

3.03 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.04 SYSTEM STARTUP

A. Prepare and start equipment in accordance with manufacturers' instructions and recommendations.

B. Adjust for proper operation within manufacturer's published tolerances.

3.05 CLEANING

A. Touch up scratched surfaces using materials recommended by manufacturer. Match touched-up paint color to factory-applied finish.

3.06 PROTECTION

A. Protect installed units from subsequent construction operations.

END OF SECTION

SECTION 329200 - TURF AND GRASSES

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:

1. Seeding.
2. Hydroseeding.
3. Turf renovation.
4. Erosion-control material(s).

B. Related Sections:

1. Division 31 Section "Site Clearing" for topsoil stripping and stockpiling.
2. Division 31 Section "Earth Moving" for excavation, filling and backfilling, and rough grading.

1.3 DEFINITIONS

A. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.

B. Finish Grade: Elevation of finished surface of planting soil.

C. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

D. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

E. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

F. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

G. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.

H. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

I. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

1. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to this Project.

B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.

C. Qualification Data: For qualified landscape Installer.

D. Product Certificates: For soil amendments and fertilizers, from manufacturer.

E. Material Test Reports: For existing native surface topsoil and existing in-place surface soil.

F. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required initial maintenance periods.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turf establishment.

1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
2. Experience: Three years' experience in turf installation in addition to requirements in Division 01 Section "Quality Requirements."
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the Professional Landcare Network:

a. Certified Landscape Technician - Exterior, with installation, maintenance specialty area(s), designated CLT-Exterior.
b. Certified Turfgrass Professional, designated CTP.
c. Certified Turfgrass Professional of Cool Season Lawns, designated CTP-CSL.

5. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.
6. Pesticide Applicator: State licensed, commercial.

B. Soil-Testing Laboratory Qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

C. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of the soil.

1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
2. The soil-testing laboratory shall oversee soil sampling, with depth, location, and number of samples to be taken per instructions from Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
3. Report suitability of tested soil for turf growth.

a. Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. or volume per cu. yd. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

D. Preinstallation Conference: Conduct conference at Project site.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.

C. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.

1.7 PROJECT CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Substantial Completion.

1. Spring Planting: March 15 – April 30.
2. Fall Planting: August 15 – October 15.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

1.8 MAINTENANCE SERVICE

A. Initial Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable turf is established but for not less than the following periods:

1. Seeded Turf: 60 days from date of Substantial Completion.

    a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

2. Sodded Turf: 30 days from date of Substantial Completion.

B. Continuing Maintenance Proposal: From Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

PART 2 - PRODUCTS

2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.

Seed Species: State-certified seed of grass species as indicated on the plans.

2.2 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:

1. Class: T, with a minimum of 99 percent passing through No. 8 sieve and a minimum of 75 percent passing through No. 60 sieve.
2. Class: O, with a minimum of 95 percent passing through No. 8 sieve and a minimum of 55 percent passing through No. 60 sieve.
3. Provide lime in form of ground dolomitic limestone.

B. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, and with a minimum of 99 percent passing through No. 6 sieve and a maximum of 10 percent passing through No. 40 sieve.

C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

D. Aluminum Sulfate: Commercial grade, unadulterated.

E. Perlite: Horticultural perlite, soil amendment grade.

F. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through No. 50 sieve.

G. Sand: Clean, washed, natural or manufactured, and free of toxic materials.

H. Diatomaceous Earth: Calcined, 90 percent silica, with approximately 140 percent water absorption capacity by weight.

I. Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

2.3 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 3/4-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 50 to 60 percent of dry weight.
2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or granular texture, with a pH range of 3.4 to 4.8.

C. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent.

D. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.

E. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

2.4 FERTILIZERS

A. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the composition indicated on the plans.

B. Planting Soil: Existing, in-place surface soil. Verify suitability of existing surface soil to produce viable planting soil. Remove stones, roots, plants, sod, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Mix surface soil with the following soil amendments and fertilizers in the quantities recommended by soil analysis for specific plantings.

1. Loose Compost.
2. Loose Sphagnum.
3. Loose Wood Derivatives.
4. Lime.
5. Sulfur, Iron Sulfate, Aluminum.
6. Agricultural Gypsum.
7. Bonemeal.
8. Superphosphate.
9. Slow-Release Fertilizer.

2.5 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

B. Sphagnum Peat Mulch: Partially decomposed sphagnum peat moss, finely divided or of granular texture, and with a pH range of 3.4 to 4.8.

C. Muck Peat Mulch: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent.

D. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 50 to 60 percent of dry weight.
2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

E. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

F. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

G. Asphalt Emulsion: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

2.6 PESTICIDES

A. General: Pesticide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

2.7 EROSION-CONTROL MATERIALS

A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.

B. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of 0.92 lb/sq. yd., with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches long.

C. Erosion-Control Mats: Cellular, non-biodegradable slope-stabilization mats designed to isolate and contain small areas of soil over steeply sloped surface, of 3-inch nominal mat thickness. Include manufacturer's recommended anchorage system for slope conditions.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

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

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
2. Protect grade stakes set by others until directed to remove them.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 TURF AREA PREPARATION

A. Limit turf subgrade preparation to areas to be planted.

B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 4 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply superphosphate fertilizer directly to subgrade before loosening.
2. Spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.

    a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
    b. Mix lime with dry soil before mixing fertilizer.

3. Spread planting soil to a depth of 4 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.

    a. Spread approximately 1/2 the thickness of planting soil over loosened subgrade. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.
    b. Reduce elevation of planting soil to allow for soil thickness of sod.

C. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:

1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
2. Loosen surface soil to a depth of at least 6 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inchesof soil. Till soil to a homogeneous mixture of fine texture.

    a. Apply superphosphate fertilizer directly to surface soil before loosening.

3. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.
4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.

D. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.

E. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

F. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 PREPARATION FOR EROSION-CONTROL MATERIALS

A. Prepare area as specified in "Turf Area Preparation" Article.

B. For erosion-control mats, install planting soil in two lifts, with second lift equal to thickness of erosion-control mats. Install erosion-control mat and fasten as recommended by material manufacturer.

C. Fill cells of erosion-control mat with planting soil and compact before planting.

D. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.

E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.5 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.

1. Do not use wet seed or seed that is moldy or otherwise damaged.

2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at rate indicated on plans.

C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas with slopes exceeding 3:1 with erosion-control blankets installed and stapled according to manufacturer's written instructions.

E. Protect seeded areas with erosion-control mats where shown on Drawings; install and anchor according to manufacturer's written instructions.

F. Protect seeded areas with slopes not exceeding 6:1 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2 inches in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.

1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.
2. Bond straw mulch by spraying with asphalt emulsion at a rate of 10 to 13 gal./1000 sq. ft.. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.

G. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch, and roll surface smooth.

3.6 HYDROSEEDING

A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.

1. Mix slurry with fiber-mulch manufacturer's recommended tackifier.
2. Apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate.
3. Apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1000 lb/acre.

3.7 TURF MAINTENANCE

A. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches.

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.

C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:

1. Kentucky bluegrass and chewings red fescue to a height of 1-1/2 to 2 inches.
2. Mow turf-type tall fescue to a height of 2 to 3 inches.

D. Turf Postfertilization: Apply fertilizer after initial mowing and when grass is dry.

1. Use fertilizer that will provide actual nitrogen of at least 1 lb/1000 sq. ft. to turf area.

3.8 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.

B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.9 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.10 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

C. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION 329200