

# PROJECT MANUAL - Part 2

*Renovations to Interior/Exterior  
and  
Install Emergency Generator Multiple Assets  
MSHP General Headquarters Complex  
Jefferson City, Missouri*

Designed By: Casco Diversified Corp.  
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STATE *of* MISSOURI

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OFFICE *of* ADMINISTRATION  
Facilities Management, Design and Construction

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## **SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING 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. Section Includes:
  - 1. Sleeves.
  - 2. Stack-sleeve fittings.
  - 3. Sleeve-seal systems.
  - 4. Sleeve-seal fittings.
  - 5. Grout.
  - 6. Silicone sealants.

#### **1.3 ACTION SUBMITTALS**

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

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Field quality-control reports.

### **PART 2 - PRODUCTS**

#### **2.1 SLEEVES**

- A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.
- B. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, **anticorrosion coated**, with plain ends and integral welded waterstop collar.
- C. Galvanized-Steel Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; 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.

## 2.2 STACK-SLEEVE FITTINGS

- A. Description: Manufactured, **Dura-coated or Duco-coated** cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
  - 1. Underdeck Clamp: Clamping ring with setscrews.

## 2.3 SLEEVE-SEAL SYSTEMS

- A. Description:
  - 1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
  - 2. Designed to form a hydrostatic seal of 20 psig (137 kPa) minimum.
  - 3. Sealing Elements: **EPDM-rubber** interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 4. Pressure Plates: **Carbon steel**.
  - 5. Connecting Bolts and Nuts: **Carbon steel, with corrosion-resistant coating, ASTM B633** of length required to secure pressure plates to sealing elements.

## 2.4 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.
- B. Plastic or rubber waterstop collar with center opening to match piping OD.

## 2.5 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 (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

## 2.6 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, ASTM C920, Type S, Grade NS, Class 25, Use NT.
- B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.
- 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

### 3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide **1-inch (25-mm)** annular clear space between piping and concrete slabs and walls.
  - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
  - 1. Cut sleeves to length for mounting flush with both surfaces.
    - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas **2 inches (50 mm)** above finished floor level.
  - 2. Using **grout or silicone sealant**, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
  - 1. Cut sleeves to length for mounting flush with both surfaces.
  - 2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
  - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.
- 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."

### 3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
  - 1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
  - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
  - 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.
  - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
  - 5. Use silicone sealant to seal the space around outside of stack-sleeve fittings.
- 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."

### 3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

### 3.4 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Use **grout or silicone sealant** to seal the space around outside of sleeve-seal fittings.

### 3.5 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.
- B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

### 3.6 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
  - 1. Exterior Concrete Walls above Grade:
    - a. Piping Smaller Than **NPS 6 (DN 150): Cast-iron pipe sleeves with sleeve-seal system, or Sleeve-seal fittings.**
  - 2. Exterior Concrete Walls below Grade:
    - a. Piping Smaller Than **NPS 6 (DN 150): Cast-iron pipe sleeves with sleeve-seal system, or Sleeve-seal fittings.**
      - 1) Select sleeve size to allow for **1-inch (25-mm)** annular clear space between piping and sleeve for installing sleeve-seal system.
  - 3. Concrete Slabs-on-Grade:
    - a. Piping Smaller Than **NPS 6 (DN 150): Cast-iron pipe sleeves with sleeve-seal system , or Sleeve-seal fittings.**
      - 1) Select sleeve size to allow for **1-inch (25-mm)** annular clear space between piping and sleeve for installing sleeve-seal system.
  - 4. Concrete Slabs above Grade:
    - a. Piping Smaller Than **NPS 6 (DN 150): Steel pipe sleeves, PVC pipe sleeves, Stack-sleeve fittings, Sleeve-seal fittings.**
  - 5. Interior Partitions:
    - a. Piping Smaller Than **NPS 6 (DN 150): Steel pipe sleeves, or PVC pipe sleeves.**

**END OF SECTION 220517**

## SECTION 220518 - ESCUTCHEONS FOR PLUMBING 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. Section Includes:
  - 1. Escutcheons.
  - 2. Floor plates.

#### 1.3 DEFINITIONS

- A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed and salvaged, or removed and reinstalled.

#### 1.4 ACTION SUBMITTALS

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

### PART 2 - PRODUCTS

#### 2.1 ESCUTCHEONS

- A. One-Piece, Steel Type: With **polished, chrome-plated** finish and setscrew fastener.
- B. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.
- C. One-Piece, Cast-Brass Type: With **polished, chrome-plated** finish and setscrew fastener.
- D. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped **steel** with polished, chrome-plated finish and spring-clip fasteners.
- E. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

- F. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; **concealed** hinge; and spring-clip fasteners.

## 2.2 FLOOR PLATES

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

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of 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.
    - d. Insulated Piping: One-piece stainless steel with polished stainless-steel finish.
    - e. Insulated Piping: One-piece cast brass with **polished, chrome-plated** finish.
    - f. Insulated Piping: One-piece stamped steel **or split-plate, stamped steel with concealed hinge** with polished, chrome-plated finish.
    - g. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with **polished, chrome-plated** finish.
    - h. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
    - i. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece cast brass with **polished, chrome-plated** finish.
    - j. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stamped steel **or split-plate, stamped steel with concealed hinge** with polished, chrome-plated finish.
    - k. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with **polished, chrome-plated** finish.
    - l. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
    - m. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast brass with **polished, chrome-plated** finish.
    - n. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped steel **or split-plate, stamped steel with concealed hinge** with polished, chrome-plated finish.
    - o. Bare Piping in Unfinished Service Spaces: One-piece steel with polished, chrome-plated finish.

- p. Bare Piping in Unfinished Service Spaces: One-piece cast brass with **polished, chrome-plated** finish.
  - q. Bare Piping in Unfinished Service Spaces: One-piece stamped steel **or split-plate, stamped steel with concealed hinge** with polished, chrome-plated finish.
  - r. Bare Piping in Equipment Rooms: One-piece steel with polished, chrome-plated finish.
  - s. Bare Piping in Equipment Rooms: One-piece cast brass with **polished, chrome-plated** finish.
  - t. Bare Piping in Equipment Rooms: One-piece stamped steel **or split-plate, stamped steel with concealed hinge** with polished, chrome-plated finish.
2. Escutcheons for Existing Piping to Remain:
- a. Chrome-Plated Piping: Split-casting, stamped steel with **concealed** hinge with polished, chrome-plated finish.
  - b. Insulated Piping: Split-plate, stamped steel with **concealed** hinge with polished, chrome-plated finish
  - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with **concealed** hinge with polished, chrome-plated finish.
  - d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with **concealed** hinge with polished, chrome-plated finish.
  - e. Bare Piping in Unfinished Service Spaces: Split-plate, stamped steel with **concealed** hinge with polished, chrome-plated finish.
  - f. Bare Piping in Equipment Rooms: 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: One-piece, floor plate.
  - 2. Existing Piping: Split floor plate.

### 3.2 FIELD QUALITY CONTROL

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

**END OF SECTION 220518**

## **SECTION 220519 - METERS AND GAGES FOR PLUMBING PIPING**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Thermometers.
  - 2. Gages.
  - 3. Test plugs.

#### **1.3 DEFINITIONS**

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

#### **1.4 SUBMITTALS**

- A. Product Data: For each type of product indicated; include performance curves.
- B. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range and location for each.
- C. Product Certificates: For each type of thermometer and gage, signed by product manufacturer.

### **PART 2 - PRODUCTS**

#### **2.1 PLASTIC-CASE, LIQUID-IN-GLASS THERMOMETERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ernst Gage Co.
  - 2. Marsh Bellofram.
  - 3. Trerice, H. O. Co.

- 4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- B. Case: Plastic, 9 inches long.
- C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.
- D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- E. Window: Glass or plastic.
- F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- G. Stem: Metal, for thermowell installation and of length to suit installation.
- H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

## **2.2 BIMETALLIC-ACTUATED DIAL THERMOMETERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
  - 2. Ernst Gage Co.
  - 3. Marsh Bellofram.
  - 4. Palmer - Wahl Instruments Inc.
  - 5. Terrice, H. O. Co.
  - 6. Weiss Instruments, Inc.
  - 7. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- B. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3.
- C. Case: Liquid-filled type, stainless steel with 5-inch diameter.
- D. Element: Bimetal coil.
- E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- F. Pointer: Red or other dark-color metal.
- G. Window: Glass.
- H. Ring: Stainless steel.
- I. Connector: Adjustable angle type.

- J. Stem: Metal, for thermowell installation and of length to suit installation.
- K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

## **2.3 THERMOWELLS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. AMETEK, Inc.; U.S. Gauge Div.
  - 2. Ernst Gage Co.
  - 3. Palmer - Wahl Instruments Inc.
  - 4. Trerice, H. O. Co.
  - 5. Weiss Instruments, Inc.
  - 6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- B. Manufacturers: Same as manufacturer of thermometer being used.
- C. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

## **2.4 PRESSURE GAGES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. AMETEK, Inc.; U.S. Gauge Div.
  - 2. Ernst Gage Co.
  - 3. Palmer - Wahl Instruments Inc.
  - 4. Trerice, H. O. Co.
  - 5. Weiss Instruments, Inc.
  - 6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
  - 1. Case: Dry type, stainless steel or cast aluminum, 4-1/2-inch diameter.
  - 2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
  - 3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
  - 4. Movement: Mechanical, with link to pressure element and connection to pointer.
  - 5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
  - 6. Pointer: Red or other dark-color metal.
  - 7. Window: Glass.
  - 8. Ring: Stainless steel.
  - 9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.



10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 22 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

C. Pressure-Gage Fittings:

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

## 2.5 TEST PLUGS

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

1. Flow Design, Inc.
2. MG Piping Products Co.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Co.
6. Trerice, H. O. Co.
7. Watts Industries, Inc.; Water Products Div.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

D. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for water service at 20 to 200 deg F shall be CR.
2. Insert material for water service at minus 30 to plus 275 deg F shall be EPDM.

E. Test Kit: Furnish one test kit containing one pressure gage and adaptor, two thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.

1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch-diameter dial and probe. Dial range shall be 0 to 200 psig.
2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F.
3. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F.
4. Carrying case shall have formed instrument padding.

## **PART 3 - EXECUTION**

### **3.1 THERMOMETER APPLICATIONS**

- A. Install liquid-in-glass direct-mounting, or bimetallic-actuated dial thermometers in the outlet of each domestic, hot-water storage tank.
- B. Provide the following temperature ranges for thermometers:
  - 1. Domestic Hot Water: 30 to 180 deg F, with 2-degree scale divisions.
  - 2. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions.

### **3.2 GAGE APPLICATIONS**

- A. Install dry-case-type pressure gages for discharge of each pressure-reducing valve.
- B. Install dry-case-type pressure gages at suction and discharge of each pump.

### **3.3 INSTALLATIONS**

- A. Install direct-mounting thermometers and adjust vertical and tilted positions.
- B. Install remote-mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.
- C. Install thermowells with socket extending to center of pipe and in vertical position in piping tees where thermometers are indicated.
- D. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.
- E. Install needle-valve and snubber fitting in piping for each pressure gage.
- F. Install test plugs in tees in piping.
- G. Install permanent indicators on walls or brackets in accessible and readable positions.
- H. Install connection fittings for attachment to portable indicators in accessible locations.
- I. Install thermometers and gages adjacent to machines and equipment to allow service and maintenance for thermometers, gages, machines, and equipment.
- J. Adjust faces of thermometers and gages to proper angle for best visibility.

## **END OF SECTION 220519**

## **SECTION 220523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

#### **1.2 SUMMARY**

- A. This Section includes general duty valves common to plumbing piping systems. Related Sections: The following Sections contain requirements that relate to this Section:
  - 1. Special purpose valves are specified in Division 22 piping system Sections.
  - 2. Valve tags and charts are specified in Division 22 Section " IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT."
- B. Section 220511 "COMMON WORK RESULTS FOR PLUMBING".

#### **1.3 SUBMITTALS**

- A. General: Submit each item in this Article according to the Conditions of the Contract and Section 22 Specification Sections.
- B. Product Data for each valve type. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions. Include list indicating valve and its application.
- C. Maintenance data for valves to include in the operation and maintenance manual specified in Division 1. Include detailed manufacturer's instructions on adjusting, servicing, disassembling, and repairing.

#### **1.4 QUALITY ASSURANCE**

- A. ASTM Compliance: Brass valves- ASTM B-61, ASTM B-62, and ASTM B-584. Silicon Brass- ASTM B-371 Alloy 694 or ASTM B-99 Alloy 651. Only valves containing 15% or less of zinc will be acceptable.
- B. ASME Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

- C. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.
- D. MSS Compliance: Comply with the various MSS Standard Practice documents referenced.
- E. NSF Compliance: NSF 61 for valve materials for potable water.

## **1.5 DELIVERY, STORAGE, AND HANDLING**

- A. Prepare valves for shipping as follows:
  - 1. Protect internal parts against rust and corrosion.
  - 2. Protect threads, flange faces, and grooves.
  - 3. Set ball valves open to minimize exposure of functional surfaces.
  - 4. Set butterfly valves closed or slightly open.
  - 5. Block check valves in either closed or open position.
- B. Use the following precautions during storage:
  - 1. Maintain valve end protection.
  - 2. Store indoors and maintain valve temperature higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use a sling to handle large valves. Rig to avoid damage to exposed parts. Do not use hand-wheels and stems as lifting or rigging points.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ball Valves:
    - a. Conbraco Industries, Inc.; Apollo Division.
    - b. Hammond Valve Corporation.
    - c. NIBCO Inc.
    - d. Stockham Valves & Fittings, Inc.
    - e. Watts
  - 2. Butterfly Valves:
    - a. General Signal; DeZurik Unit.
    - b. Grinnell Corp.
    - c. Hammond Valve Corporation.

- d. Keystone Valve USA, Inc.
  - e. NIBCO Inc.
  - f. Stockham Valves & Fittings, Inc.
  - g. Watts
- 3. Swing Check Valves:
  - a. Cla-Val Co.
  - b. Hammond Valve Corporation.
  - c. NIBCO Inc.
  - d. Powell: Wm. Powell Company (The).
  - e. Stockham Valves & Fittings, Inc.
  - f. Watts
- 4. Wafer Check Valves:
  - a. Hammond Valve Corporation.
  - b. NIBCO Inc.
  - c. Stockham Valves & Fittings, Inc.
  - d. Watts

## **2.2 BASIC, COMMON FEATURES**

- A. Pressure and Temperature Ratings: As indicated in the "Application Schedule" of Part 3 of this Section and as required to suit system pressures and temperatures.
- B. Sizes: Same size as upstream pipe, unless otherwise indicated.
- C. Operators: Use specified operators and handwheels, except provide the following special operator features:
  - 1. Handwheels: For valves other than quarter turn.
  - 2. Lever Handles: For quarter-turn valves 4 inches and smaller.
  - 3. Gear-Drive Operators: For quarter-turn valves 6 inches and larger.
- D. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.
- E. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.
- F. Threads: ASME B1.20.1.
- G. Flanges: ASME B16.1 for cast iron, ASME B16.5 for steel, and ASME B16.24 for bronze valves.

## **2.3 BALL VALVES**

- A. Ball Valves, 4 Inches and Smaller: MSS SP-110, Class 150, 600-psi CWP, ASTM B 584 bronze body and bonnet, 2-piece construction; chrome-plated brass ball, full port for 1-inch valves and smaller and conventional port for 1-1/4-inch valves and larger; blowout proof; bronze or brass stem; teflon seats and seals; threaded or soldered end connections:
1. Operator: Vinyl-covered steel lever handle.
  2. Operator: Lever operators with lock where called for on the drawings.
  3. Stem Extension: For valves installed in insulated piping.
  4. Memory Stop: For operator handles.

## **2.4 BUTTERFLY VALVES**

- A. Butterfly Valves: MSS SP-67, 200-psi CWP, 150-psi maximum pressure differential, ASTM A 126 cast-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals, wafer, lug, or grooved style:
1. Disc Type: Nickel-plated ductile iron.
  2. Disc Type: Epoxy-coated ductile iron.
  3. Operator for Sizes 2-1/2 Inches to 4 Inches : Lever handle with latch lock.
  4. Operator for Sizes 6 Inches and larger: Gear operator with position indicator.
  5. Operator for Sizes 6 Inches and Larger, 96 Inches or Higher above Floor: Chain-wheel operator.

## **2.5 CHECK VALVES**

- A. Swing Check Valves, 2-1/2 Inches and Smaller: MSS SP-80; Class 125, 200-psi CWP, or Class 150, 300-psi CWP; horizontal swing, Y-pattern, ASTM B 62 cast-bronze body and cap, rotating bronze disc with rubber seat or composition seat, threaded or soldered end connections:
- B. Swing Check Valves, 3 Inches and Larger: MSS SP-71, Class 125, 200-psi CWP, ASTM A 126 cast-iron body and bolted cap, horizontal-swing bronze disc, flanged or grooved end connections.
- C. Wafer Check Valves: Class 125, 200-psi CWP, ASTM A 126 cast-iron body, bronze disc/plates, stainless-steel pins and springs, Buna N seals, installed between flanges.
- D. Check Valves-Vertical Position: Check Valves used in vertical position shall be Mueller Steam Specialty Co., Figure 105-BP glove type, bronze body, flanged ends, 175# W.W.P., seats and disc of composition bronze, guide pins and bushings of silicon bronze, phosphor bronze springs. The units shall be designed for quiet action and positive protection against water hammer.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.
- D. Examine threads on valve and mating pipe for form and cleanliness.
- E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.
- F. Do not attempt to repair defective valves; replace with new valves.

### **3.2 INSTALLATION**

- A. Install valves as indicated, according to manufacturer's written instructions.
- B. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.
- C. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.
- D. Locate valves for easy access and provide separate support where necessary.
- E. Install valves in horizontal piping with stem at or above the center of the pipe.
- F. Install valves in a position to allow full stem movement.
- G. For chain-wheel operators, extend chains to 60 inches above finished floor elevation.
- H. Installation of Check Valves: Install for proper direction of flow as follows:
  - 1. Swing Check Valves: Horizontal position with hinge pin level.
  - 2. Wafer Check Valves: Horizontal or vertical position, between flanges.

### **3.3 THREADED CONNECTIONS**

- A. Note the 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.
- B. Align threads at point of assembly.

- C. Apply appropriate tape or thread compound to the external pipe threads, except where dry seal threading is specified.
- D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

### **3.4 FLANGED CONNECTIONS**

- A. Align flange surfaces parallel.
- B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.
- C. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

### **3.5 VALVE END SELECTION**

- A. Select valves with the following ends or types of pipe/tube connections:
  - 1. Copper Tube Size, 2 Inches and Smaller: Threaded ends.
  - 2. Copper Tube Size 2-1/2 Inches and Larger: Flanged ends.

### **3.6 APPLICATION SCHEDULE**

- A. General Application: Use gate, ball, and butterfly valves for shutoff duty; globe, ball, and butterfly for throttling duty. Refer to piping system Specification Sections for specific valve applications and arrangements.
- B. Domestic Water Systems: Use the following valve types:
  - 1. Ball Valves: Class 150, 600-psi CWP, with stem extension.
  - 2. Butterfly Valves: Nickel-plated ductile iron or elastomer-coated ductile iron disc; EPDM or Buna N sleeve and stem seals.
  - 3. Bronze Swing Check: Class 125, with rubber seat.
  - 4. Check Valves: Class 125, swing or wafer type as indicated.

**END OF SECTION 220523**



## **SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

#### **1.2 SUMMARY**

- A. This Section includes the following hangers and supports for plumbing system piping and equipment:
  - 1. Steel pipe hangers and supports.
  - 2. Trapeze pipe hangers.
  - 3. Thermal-hanger shield inserts.
  - 4. Fastener systems.
  - 5. Pipe stands.
  - 6. Pipe positioning systems.
  - 7. Equipment supports.
- B. Related Sections include the following:
  - 1. Division 5 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.

#### **1.3 DEFINITIONS**

- A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

#### **1.4 PERFORMANCE REQUIREMENTS**

- A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

- C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

## **1.5 SUBMITTALS**

- A. Product Data: For the following:
  - 1. Steel pipe hangers and supports.
  - 2. Thermal-hanger shield inserts.
  - 3. Powder-actuated fastener systems.
  - 4. Pipe positioning systems.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
  - 1. Trapeze pipe hangers. Include Product Data for components.
  - 2. Metal framing systems. Include Product Data for components.
  - 3. Pipe stands. Include Product Data for components.
  - 4. Equipment supports.
- C. Welding certificates.

## **1.6 QUALITY ASSURANCE**

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

### **2.2 STEEL PIPE HANGERS AND SUPPORTS**

- A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.
- B. Manufacturers:
  - 1. B-Line Systems, Inc.; a division of Cooper Industries.

2. Empire Industries, Inc.
3. Globe Pipe Hanger Products, Inc.
4. Grinnell Corp.
5. GS Metals Corp.
6. National Pipe Hanger Corporation.
7. Piping Technology & Products, Inc.
8. Tolco Inc.

- C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.
- E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

## **2.3 TRAPEZE PIPE HANGERS**

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

## **2.4 METAL FRAMING SYSTEMS**

- A. Description: MFMA-3, Shop or field fabricated pipe support assembly made of steel channels and other components.
- B. Manufacturers:
1. B-Line Systems, Inc.; A Division of Cooper Industries.
  2. Erico/Michigan Hanger Co.; Eri strut Division.
  3. GS Metals Corporation.
  4. Tolco, Inc.
  5. Unistrut Corp.; Tyco International, Ltd.
- C. Nonmetallic Coatings: Plastic coating, jacket or liner.

## **2.5 THERMAL-HANGER SHIELD INSERTS**

- A. Description: 100-psig-minimum, compressive-strength insulation insert encased in sheet metal shield.
- B. Manufacturers:
1. Carpenter & Paterson, Inc.
  2. ERICO/Michigan Hanger Co.
  3. PHS Industries, Inc.
  4. Pipe Shields, Inc.

5. Rilco Manufacturing Company, Inc.

- C. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with vapor barrier.
- D. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass, with vapor barrier.
- E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

## 2.6 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.
  - 1. Manufacturers:
    - a. Hilti, Inc.
    - b. ITW Ramset/Red Head.
    - c. Masterset Fastening Systems, Inc.
    - d. MKT Fastening, LLC.
    - e. Powers Fasteners.
- B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
  - 1. Manufacturers:
    - a. B-Line Systems, Inc.; a division of Cooper Industries.
    - b. Empire Industries, Inc.
    - c. Hilti, Inc.
    - d. ITW Ramset/Red Head.
    - e. MKT Fastening, LLC.
    - f. Powers Fasteners.

## 2.7 PIPE STAND FABRICATION

- A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

## **2.8 PIPE POSITIONING SYSTEMS**

- A. Description: IAPMO PS 42, system of metal brackets, clips, and straps for positioning piping in pipe spaces for plumbing fixtures for commercial applications.
- B. Manufacturers:
  - 1. C & S Mfg. Corp.
  - 2. HOLDRITE Corp.; Hubbard Enterprises.
  - 3. Samco Stamping, Inc.

## **2.9 EQUIPMENT SUPPORTS**

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

## **2.10 MISCELLANEOUS MATERIALS**

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

## **PART 3 - EXECUTION**

### **3.1 HANGER AND SUPPORT APPLICATIONS**

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use padded hangers for piping that is subject to scratching.
- F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
  2. 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.
  3. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
  4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
  5. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
  6. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
  7. 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.
  8. 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 not necessary.
  9. 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 not necessary.
- G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
  2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
  2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
  3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
  4. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction to attach to top flange of structural shape.
  2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
  3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
  4. C-Clamps (MSS Type 23): For structural shapes.
  5. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.

6. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
  7. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
- J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
  2. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- K. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- L. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
- M. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

### **3.2 HANGER AND SUPPORT INSTALLATION**

- A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
  2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- D. Pipe Stand Installation:
1. Pipe Stand Types: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
- E. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Division 15 Section "Plumbing Fixtures" for plumbing fixtures. Support devices shall be such that applied insulation undisturbed within supporting system.

- F. Install hangers and supports complete with necessary 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 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.
- K. Load Distribution: Install hangers and supports so 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 so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.
- M. Insulated Piping: Comply with the following:
  - 1. Attach clamps and spacers to piping.
    - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    - c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.
  - 2. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
    - 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. 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.
  - 4. Insert Material: Length at least as long as protective shield.
  - 5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.



### **3.3 EQUIPMENT SUPPORTS**

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

### **3.4 METAL FABRICATIONS**

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

### **3.5 ADJUSTING**

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

### **3.6 PAINTING**

- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 painting Sections.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

General Headquarters Complex  
Renovations to Interior/Exterior & Install Emergency Generator  
Multiple Assets  
Jefferson City, MO

State Project Number: R2502-01

**END OF SECTION 220529**

## **SECTION 220548 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. 2005 ASCE (American Society of Civil Engineers) 7 – Minimum Design Loads for Buildings and Other Structures.
- C. SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems (latest edition).
- D. International Code Council (ICC) Evaluation Service Program-provided seismic restraint, anchorage, and only bracing guidelines and details (latest editions).

#### **1.2 SUMMARY**

- A. This Section includes designing, furnishing, and installing the following:
  - 1. Hangers and supports for plumbing equipment and systems.
  - 2. Seismic restraints for plumbing equipment and systems.
  - 3. Concrete bases for mechanical, plumbing or fire protection equipment.

#### **1.3 DEFINITIONS**

- A. ASTM: American Society for Testing and Materials
- B. AWS: American Welding Society
- C. IBC: International Building Code (2009 IBC)
- D. ICC: International Code Council.
- E. MFMA: Metal Framing Manufacturer's Association.
- F. MSS: Manufacturer's Standardization Society.
- G. NBC: National Building Code (latest edition).
- H. NFPA: National Fire Protection Association.

- I. Seismic Restraint: A structural support element (such as a metal framing member, a cable, an anchor bolt or stud, a fastening device, or an assembly of these items) used to transfer seismic forces from an item of equipment or system to a building structural element and/or to limit movement of such item during a seismic event.
- J. SMACNA: Sheet Metal and Air Conditioning Contractor's National Association.

#### **1.4 SUBMITTALS**

- A. Product Data submitted shall illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of electrical support or seismic-restraint component used:
  - 1. Tabulate types, sizes and points of application of all seismic restraints, anchorages, sway bracing and other support elements to be used complete with report on numbers and rated strength in tension and shear, as evaluated by an agency acceptable to authorities having jurisdiction.
  - 2. Annotate to indicate application point of each product submitted and to document compliance with requirements.
- B. Shop Drawings submitted shall indicate materials and dimensions as well as identify hardware, (including attachment and anchorage devices), identify seismic support locations, all signed and sealed by a qualified registered professional engineer. Professional engineer qualification requirements are specified in Division 1 of this Specification include the following, as a minimum:
  - 1. Fabricated Supports: Representations of field-fabricated supports for all required locations.
  - 2. Seismic Restraints: Detailing anchorage bracing, and location. Include the following:
    - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads. Include location of designed restraint.
    - b. Details: Fabrication and arrangement, as well as attachments of restraints to the restrained items and to the structure shall be detailed. 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.
    - c. Pre-approval and Evaluation Documentation from by an agency acceptable to authorities having jurisdiction shall be submitted, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
    - d. Location: Identify by tables or drawings all required seismic restraint locations and associated restraints for this Project.
  - 3. Contractor is hereby cautioned that the design of the anchorages, sway bracing, seismic restraints, and other support elements required to be completed under this Section of this Specification by a qualified, registered professional engineer may NOT be accomplished solely by means of general references to published design manuals, tables, standard details, or other such references from Accepted Engineering Practice documents. However, incorporating such information, tables, details, or other published reference

material directly into the specific design of such anchorages, sway bracing, seismic restraints, and other support elements required to be completed under this Section of this Specification (that will ultimately be signed and sealed by the registered professional engineer prior to submittal) is permissible.

- C. Coordination Drawings shall show coordination of seismic bracing for mechanical, plumbing and fire protection components with other systems and equipment in the vicinity, including other supports and seismic restraints.
- D. Welding certificates shall be submitted, as appropriate.
- E. Qualification Data for registered professional design engineer and testing agency shall be submitted.
- F. Field quality-control test reports shall be submitted.

## **1.5 QUALITY ASSURANCE**

- A. Comply with seismic-restraint requirements in the IBC, unless requirements in these Contract Documents are more stringent.
- B. Testing of Seismic Anchorage Devices: Comply with testing requirements in Part 3 of this Specification Section.
- C. Welding: Qualify welding procedures and welding personnel capabilities according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- D. Seismic restraint devices shall have been subjected to both horizontal and vertical load testing and analysis acceptable to authorities having jurisdiction, showing maximum seismic restraint ratings.

Ratings based on independent testing are preferred to ratings based on calculations. Testing and/or calculations must include both shear and tensile loads (including combined shear and tensile loads), and one test or analysis at 45 degrees to the weakest mode.

## **1.6 PROJECT CONDITIONS**

- A. See Table(s) on Structural Drawings for specific project seismic conditions.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. In other Part 2 articles where titles below introduce lists of acceptable manufacturers, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified or Engineer-approved equal.

## **2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS**

- A. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed on mechanical and plumbing system components for this Project, with a minimum structural safety factor of five (5) times the applied force.
- B. Steel Slotted Support Systems shall comply with MFMA-3, factory-fabricated components for field assembly.
  1. Acceptable Manufacturers:
    - a. Cooper B-Line; a division of Cooper Industries.
    - b. ERICO International Corporation.
    - c. Allied Support Systems; Power-Strut Unit.
    - d. GS Metals Corp.
    - e. Michigan Hanger Co., Inc.; O-Strut Div.
    - f. National Pipe Hanger Corp.
    - g. Thomas & Betts Corporation.
    - h. Unistrut; Tyco International, Ltd.
    - i. Wesanco, Inc.
    - j. Engineer-approved equal.
  2. Finishes:
    - a. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-3.
    - b. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-3.
  3. Channel Dimension shall be selected for structural loading condition and applicable seismic forces.
- C. Raceway and Cable Tray Support shall be as described in the IBC and ASCE 7 documents.
- D. Conduit and Cable Support Device shall be steel hangers, clamps, and associated fittings, specifically designed for the types and sizes of raceway or pipe to be supported.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Requirements for items for fastening mechanical or plumbing items or their supports to building surfaces shall include the following:
  1. Verify suitability of all fasteners for use with lightweight concrete or concrete slabs less than 4 inches thick.

2. Powder-Actuated Fasteners shall be threaded-steel stud, for use in hardened portland cement concrete, steel, or wood; with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
  - a. Acceptable Manufacturers:
    - 1) Hilti, Inc.
    - 2) ITW Construction Products.
    - 3) MKT Fastening, LLC.
    - 4) Simpson Strong-Tie Co. Inc.
    - 5) Engineer-approved equal.
3. Mechanical-Expansion Anchors shall be 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 in which used.
  - a. Acceptable Manufacturers:
    - 1) Cooper B-Line; a division of Cooper Industries.
    - 2) Empire Tool and Manufacturing Co., Inc
    - 3) Hilti, Inc.
    - 4) ITW Construction Products.
    - 5) MKT Fastening, LLC.
    - 6) Powers Fasteners.
    - 7) Engineer-approved equal.
4. Concrete Inserts shall be steel or malleable-iron slotted-support-system units similar to MSS Type 18; complying with MFMA-3 or MSS SP-58.
5. Clamps for Attachment to Steel Structural Elements shall conform to MSS SP-58, type suitable for attached structural element.
6. Through Bolts shall be structural type, hex head, high-strength. Comply with ASTM A 325.
7. Toggle Bolts shall be all-steel springhead type.
8. Hanger Rods shall be threaded steel.

## **2.3 SEISMIC RESTRAINT COMPONENTS**

### **A. Manufacturers:**

1. Amber/Booth Company, Inc.
2. B-Line Systems, Inc.
3. California Dynamics Corp.
4. Kinetics Noise Control, Inc.
5. Loos & Co., Inc.; Cableware Technology Division.
6. Mason Industries, Inc.
7. Unistrut Diversified Products Co.; Wayne Manufacturing Division.
8. Vibration Eliminator Co., Inc.
9. Vibration Isolation Co., Inc.

10. Vibration Mountings & Controls/Korfund.

- B. Rated Strength, Features, and Application Requirements for Restraint Components shall be as defined by an agency acceptable to authorities having jurisdiction.
  - 1. Structural Safety Factor: Strength in tension, shear, and pullout force of components used shall be at least five (5) times the maximum seismic forces to which they will be subjected.
- C. Angle and Channel-Type Brace Assemblies: Steel angles or steel slotted-support-system components; with accessories for attachment to braced component at one end and to building structure at the other end.
- D. Cable Restraints: ASTM A 603, zinc-coated, steel wire rope attached to steel or stainless-steel thimbles, brackets, swivels, and bolts designed for restraining cable service.
- E. Seismic Mountings, Anchors, and Attachments: For this application, items shall be selected to resist seismic forces.
  - 1. Hanger Rod Stiffeners shall be steel tube or steel slotted-support-system sleeves with internally bolted connections or reinforcing steel angle clamped to hanger rod, of design recognized by an agency acceptable to authorities having jurisdiction.
  - 2. Bushings for Floor-Mounted Equipment Anchors shall be neoprene units designed for seismically rated rigid equipment mountings, and matched to type and size of anchor bolts and studs used.
  - 3. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves shall be designed for seismically-rated rigid equipment mountings, and matched to type and size of attachment devices used.
- F. Seismic Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
  - 1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
  - 2. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer of 50, plus or minus 5.

**2.4 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES**

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

**PART 3 - EXECUTION**



### **3.1 GENERAL REQUIREMENTS**

- A. Comply with IBC for specific application requirements for hangers and supports for mechanical and plumbing equipment and systems, except if requirements in these Contract Documents are stricter.
- B. Multiple Raceways or Pipes: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits; and:
  - 1. Secure raceways and pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
  - 2. Secure raceways and pipes to these supports with two-bolt pipe clamps.
- C. Spring-steel clamps designed for supporting single pipes without bolts may be used for 1-1/2-inch and smaller raceways, and for fastening raceways to trapeze supports.
- D. Install all supports, restraints, attachments, and other elements specified in this Section of this Specification in strict conformance with the written installation requirements of the manufacturers of each support, restraint, attachment, or other element.

### **3.2 SUPPORT AND SEISMIC RESTRAINT INSTALLATION**

- A. Comply with SMACNA and MSS for installation requirements, except as otherwise specified in this Article of this Section of this Specification.
- B. Install seismic restraint components using methods approved by the evaluation service providing required submittals for component.
- C. Strength of Support and Seismic Restraint Assemblies: Where not otherwise indicated, select sizes of components so that strength will be adequate to carry present and future static and seismic loads within specified loading limits. Minimum static design load used for strength determination shall be the weight of the supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten mechanical and plumbing 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: Use approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  - 4. To Existing Concrete: Fasten with expansion anchors.
  - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.

6. To Steel: Use welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts or beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 or Spring-tension clamps.
  7. To Light Steel: Use sheet metal screws.
  8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount such devices on slotted-channel racks attached to substrate by means that meet seismic restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in reinforced concrete at locations and to depths that avoid reinforcing bars.

### **3.3 INSTALLATION OF FABRICATED METAL SUPPORTS**

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Field Welding: Comply with AWS D1.1/D1.1M.

### **3.4 CONCRETE BASES**

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and seismic requirements for Project.
- B. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and such that expansion anchors will be a minimum of 10 bolt diameters from edge of the base; and:
  1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of the base.
  2. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
  3. Place and secure anchorage devices using the equipment to be supported manufacturer's 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. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
  6. Use 3000-psi, 28-day compressive-strength concrete, minimum.

### **3.5 INSTALLATION OF SEISMIC RESTRAINT COMPONENTS**

- A. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- B. 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.

- C. Restraint Cables shall be installed with slack within maximum tolerance recommended by cable manufacturer.
- D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, upper truss chords of bar joists, or at concrete members.

### **3.6 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION**

- A. Make flexible connections in runs of raceways and piping where they cross expansion and seismic control joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to mechanical and plumbing equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

### **3.7 FIELD QUALITY CONTROL TESTS**

- A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Record test results and submit to Engineer.
- C. Test pullout resistance of seismic anchorage devices, and:
  - 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
  - 2. Schedule test with Owner and Engineer present before connecting anchorage devices to components to be restrained (unless post-connection testing has been approved by Engineer in advance). Provide at least 7 days advance notice of scheduled test.
  - 3. Obtain Engineer's concurrence before transferring test loads to structure. Provide temporary load-spreading members.
  - 4. Test at least four of each type and size of installed anchorages and fasteners.
  - 5. Test anchorages and fasteners to 90 percent of rated proof load of item.
  - 6. If any item fails test, modify all installations of same type for project, then retest item until satisfactory test result is achieved.

### **3.8 PAINTING AND FINISHING**

- A. Refer to Division 09 Finishes for field painting requirements.
- B. Damage and Touch-Up: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

### **3.9 CUTTING AND PATCHING**

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of the trades involved.
- B. Repair cut surfaces to match adjacent surfaces.

### **3.10 GROUTING**

- A. Install non-metallic, non-shrink grout for mechanical equipment base bearing surfaces, pump and other equipment base plates and anchors. Mix grout according to manufacturer's printed instructions.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms for placement of grout, as required.
- D. Avoid air entrapment when placing grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases to provide a smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout according to manufacturer's printed instructions.

**END OF SECTION 220548**

## **SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Equipment labels.
  - 2. Warning signs and labels.
  - 3. Pipe labels.
  - 4. Stencils.
  - 5. Valve tags.
  - 6. Warning tags.

#### **1.3 SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system to include in maintenance manuals.

#### **1.4 COORDINATION**

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

## **PART 2 - PRODUCTS**

### **2.1 EQUIPMENT LABELS**

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch, Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. 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), plus 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), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

### **2.2 WARNING SIGNS AND LABELS**

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: Black.
- C. Background Color: Yellow.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2 inch by 5 inch.
- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information, plus emergency notification instructions.

## **2.3 PIPE LABELS**

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed vinyl with pressure-sensitive, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, 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 1-1/2 inches high.

## **2.4 VALVE TAGS**

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
  - 1. Tag Material: 1½" Diameter, Brass, 0.032-inch, minimum thickness, and having predrilled or stamped holes for attachment hardware.
  - 2. Fasteners: Brass #6 bead chain or #16 brass jack 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. Valve-tag schedule shall be included in operation and maintenance data.

## **2.5 WARNING TAGS**

- A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
  - 1. Size: 2 by 5 inches minimum.

2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

## **PART 3 - EXECUTION**

### **3.1 PREPARATION**

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

### **3.2 EQUIPMENT LABEL INSTALLATION**

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

### **3.3 PIPE LABEL INSTALLATION**

- A. Piping Color-Coding: Painting of piping is specified in Division 9 Section "High-Performance Coatings."
- B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
  1. Near each valve and control device.
  2. Near each branch connection, excluding short takeoffs for 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 25 feet along each run.
- C. Pipe Label Color Schedule:
  1. Domestic Water Piping:
    - a. Background Color: White.
    - b. Letter Color: Green.
  2. Sanitary Waste, Vent and Storm Drainage Piping:



- a. Background Color: White.
- b. Letter Color: Red.

### **3.4 VALVE-TAG INSTALLATION**

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
  - 1. Valve-Tag Size and Shape:
    - a. Cold Water: 1-1/2 inches, round.
    - b. Hot Water: 1-1/2 inches, round.
  - 2. Chains shall be attached to valve lever handle or around valve system.
  - 3. Valve tags located above lay-in ceiling shall be hung where tag hangs below the level of the piping.

### **3.5 WARNING-TAG INSTALLATION**

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

**END OF SECTION 220553**

## **SECTION 220593 - TESTING, ADJUSTING, AND BALANCING FOR PLUMBING**

### **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. TAB of domestic water system.
  - 2. TAB of plumbing equipment:
    - a. Domestic hot-water in-line circulation pumps.
    - b. Sanitary sewage pumps.
  - 3. Pipe-leakage test verification.

#### **1.3 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.

#### **1.4 PREINSTALLATION MEETINGS**

- A. TAB Conference: Conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan, to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.
  - 1. Minimum Agenda Items:

- a. The Contract Documents examination report.
- b. The TAB plan.
- c. Needs for coordination and cooperation of trades and subcontractors.
- d. Proposed procedures for documentation and communication flow.

## **1.5 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. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.
- C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.
- D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article.
- E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- F. Certified TAB reports.
- G. Sample report forms.
- H. 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.

## **1.6 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. TAB Specialists Qualifications, Certified by NEBB or TABB:
  1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
  2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB.

- C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- D. ASHRAE 111 Compliance: Requirements in ASHRAE 111 applicable to analogous domestic water system and plumbing equipment balancing.
- E. ASHRAE 188 Compliance: Comply with balancing and report requirements, Section 8.3 "Balancing."
- F. Code and Authorities Having Jurisdiction Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

## **1.7 FIELD CONDITIONS**

- A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

## **PART 2 - PRODUCTS (Not Applicable)**

## **PART 3 - EXECUTION**

### **3.1 TAB SPECIALISTS**

- A. Subject to compliance with requirements, available TAB specialists that may be engaged include, but are not limited to, the following:

### **3.2 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, and balancing valves and fittings. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine approved submittals for plumbing systems and equipment.
- D. Examine design data, including plumbing system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about plumbing system and equipment controls.
- E. Examine equipment performance data, including pump curves.

1. Relate performance data to Project conditions and requirements, including pump system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
  2. Calculate pump system-effect factors to reduce performance ratings of plumbing equipment when installed under conditions different from the conditions used to rate equipment performance. Compare results with the design data and installed conditions.
- F. Examine system and equipment installations, and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- G. Examine test reports specified in individual system and equipment Sections.
- H. Examine plumbing equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- I. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainers are installed and clean.
- J. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.
- K. Examine system pumps to ensure absence of entrained air in the suction piping.
- L. Examine operating safety interlocks and controls on plumbing equipment.
- M. 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.

### **3.3 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 plumbing systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
1. Domestic Water System:
    - a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed in accordance with applicable code and authority having jurisdiction.
    - b. Water heaters are installed and functioning.

- c. Piping is complete and all points of outlet are installed.
  - d. Water treatment is complete.
  - e. Systems are flushed, filled, and air purged.
  - f. Strainers are clean.
  - g. Control valves are functioning in accordance with the sequence of operation.
  - h. Shutoff and balance valves are 100 percent open.
  - i. Hot-water circulating pumps are operational and proper rotation is verified.
  - j. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
  - k. Variable-frequency controllers' startup is complete and safeties are verified.
  - l. Suitable access to balancing devices and equipment is provided.
2. Sanitary Sewage/Drainage System:
- a. Leakage and pressure tests on sanitary sewage/drainage systems have been completed in accordance with applicable code and authority having jurisdiction requirements.
  - b. Piping is complete.
  - c. Sanitary sewage pumps/drainage pumps are operational.
  - d. Control valves are functioning in accordance with the sequence of operation.
  - e. Shutoff valves are 100 percent open.
  - f. Suitable access to equipment is provided.

### **3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING**

- A. Perform testing and balancing procedures on each system in accordance with the procedures contained in AABC's "National Standards for Total System Balance" and in this Section.
- B. Cut insulation, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
  - 1. Where holes for probes are required in piping or equipment, install pressure and temperature test plugs to seal systems.
  - 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 220716 "Plumbing Equipment Insulation" and Section 220719 "Plumbing Piping Insulation."
- C. Mark equipment and balancing devices, including valve position indicators 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)** units.

### **3.5 GENERAL PROCEDURES FOR PLUMBING EQUIPMENT**

- A. Test, adjust, and balance plumbing equipment indicated on Drawings, including, but not limited to, the following:

1. Domestic water in-line pumps.
2. Domestic water heaters.
3. Drainage pumps.

### **3.6 PROCEDURES FOR DOMESTIC WATER SYSTEMS**

- A. Prepare test reports for pumps and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required equipment flow rates with system design flow rates.
- B. Prepare schematic diagrams of systems' Record drawings piping layouts.
- C. In addition to requirements in "Preparation" Article, prepare domestic water systems for testing and balancing as follows:
  1. Check expansion tank for proper setting.
  2. Check water heater for proper discharge temperature setting.
  3. Check remotest point of outlet for adequate pressure.
  4. Check flow-control valves for proper position.
  5. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
  6. Verify that motor controllers are equipped with properly sized thermal protection.
  7. 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.
- G. Check settings and operation of each safety valve. Record settings.

### **3.7 PROCEDURES FOR DOMESTIC HOT-WATER CIRCULATING INLINE PUMP**

- A. Balance system with manual or automatic balancing valves by setting at design flow.
  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.
- B. Adjust pump to deliver total design flow.
  1. 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.
2. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
3. Mark final settings and verify that all memory stops have been set.
4. Verify final system conditions as follows:
  - a. Re-measure and confirm that total flow is within design.
  - b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
  - c. Mark final settings.

### **3.8 PROCEDURES FOR WATER HEATERS**

#### **A. Gas- and Oil-Fired Water Heaters:**

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 (kW)** of heating output.
6. Fuel Consumption: If 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.

### **3.9 TOLERANCES**

#### **A. Set plumbing system's flow rates within the following tolerances:**

1. Domestic Water Flow Rate: Plus 10 percent or minus 5 percent. If design value is less than **10 gpm (0.63 L/s)**, within 10 percent.

### **3.10 PROGRESS REPORTING**

- #### **A. Initial Construction-Phase Report:** Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to plumbing systems and general construction to allow access for performance-measuring and -balancing devices.



- B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

### **3.11 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. Manufacturers' test data.
  - 3. Field test reports prepared by system and equipment installers.
  - 4. 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. Notes to explain why certain final data in the body of reports vary from indicated values.
  - 14. 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 distribution systems. Present each system with single-line diagram and include the following:
  - 1. Flow rates.
  - 2. Pipe and valve sizes and locations.
  - 3. Balancing stations.
  - 4. Position of balancing devices.
- E. Gas- and Oil-Fired Water Heaters 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 (kW)**.
    - 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 (mm)**, and bore.
    - n. Center-to-center dimensions of sheave and amount of adjustments in **inches (mm)**.
  - 2. Test Data (Indicated and Actual Values):
    - a. Total airflow rate in **cfm (L/s)**.
    - b. Entering-water temperature in **deg F (deg C)**.
    - c. Leaving-water temperature in **deg F (deg C)**.
    - d. Low-fire fuel input in **Btu/h (kW)**.
    - e. High-fire fuel input in **Btu/h (kW)**.
    - f. High-temperature-limit setting in **deg F (deg C)**.
    - g. Operating set point in **Btu/h (kW)**.
    - h. Heating value of fuel in **Btu/h (kW)**.
- F. Electric Water Heater Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
  - 1. Unit Data:
    - a. System identification.
    - b. Location.

- c. Model number and unit size.
    - d. Manufacturer's serial number.
    - e. Output capacity in **Btu/h (kW)**.
    - f. Number of stages.
    - g. Connected volts, phase, and hertz.
    - h. Rated amperage.
  2. Test Data (Indicated and Actual Values):
    - a. Heat output in **Btu/h (kW)**.
    - b. Entering-water temperature in **deg F (deg C)**.
    - c. Leaving-water temperature in **deg F (deg C)**.
    - d. High-temperature-limit setting in **deg F (deg C)**.
    - e. Operating set point in **deg F (deg C)**.
    - f. Voltage at each connection.
    - g. Amperage for each phase.
- G. 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 (L/s)**.
    - g. Water-pressure differential in **feet of head or psig (kPa)**.
    - h. Required net positive suction head in **feet of head or psig (kPa)**.
    - i. Pump speed.
    - j. Impeller diameter in **inches (mm)**.
    - k. Motor make and frame size.
    - l. Motor horsepower and rpm.
    - m. Voltage at each connection.
    - n. Amperage for each phase.
    - o. Full-load amperage and service factor.
    - p. Seal type.
  2. Test Data (Indicated and Actual Values):
    - a. Static head in **feet of head or psig (kPa)**.
    - b. Pump shutoff pressure in **feet of head or psig (kPa)**.
    - c. Actual impeller size in **inches (mm)**.
    - d. Full-open flow rate in **gpm (L/s)**.
    - e. Full-open pressure in **feet of head or psig (kPa)**.
    - f. Final discharge pressure in **feet of head or psig (kPa)**.
    - g. Final suction pressure in **feet of head or psig (kPa)**.
    - h. Final total pressure in **feet of head or psig (kPa)**.

- i. Final water flow rate in **gpm** (L/s).
- j. Voltage at each connection.
- k. Amperage for each phase.

H. Instrument Calibration Reports:

1. Report Data:

- a. Instrument type and make.
- b. Serial number.
- c. Application.
- d. Dates of use.
- e. Dates of calibration.

### 3.12 VERIFICATION OF TAB REPORT

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Construction Manager.
- B. Construction Manager shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to the lesser of either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
- C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the TAB shall be considered incomplete and shall be rejected.
- E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:
  - 1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes shall be tracked to show changes made to previous report.
  - 2. If the second final inspection also fails, Owner may pursue other Contract options to complete TAB work.
- F. Prepare test and inspection reports.

### 3.13 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

General Headquarters Complex  
Renovations to Interior/Exterior & Install Emergency Generator  
Multiple Assets  
Jefferson City, MO

State Project Number: R2502-01

**END OF SECTION 220593**

## **SECTION 220719 - PLUMING INSULATION**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Insulation Materials:
    - a. Flexible elastomeric.
    - b. Mineral fiber.
    - c. Cellular glass.
  - 2. Insulating cements.
  - 3. Adhesives.
  - 4. Mastics.
  - 5. Lagging adhesives.
  - 6. Sealants.
  - 7. Factory-applied jackets.
  - 8. Field-applied fabric-reinforcing mesh.
  - 9. Field-applied cloths.
  - 10. Field-applied jackets.
  - 11. Tapes.
  - 12. Securements.
  - 13. Corner angles.

#### **1.3 SUBMITTALS**

- A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).
- B. Shop Drawings:
  - 1. Application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
  - 2. Insulation application at pipe expansion joints for each type of insulation.

3. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
4. Removable insulation at piping specialties, equipment connections, and access panels.
5. Application of field-applied jackets.

#### **1.4 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. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
  1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

#### **1.5 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.

#### **1.6 COORDINATION**

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 Section "Hangers and Supports."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. 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.

#### **1.7 SCHEDULING**

- A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

## **PART 2 - PRODUCTS**

### **2.1 INSULATION MATERIALS**

- A. Comply with requirements in Part 3 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. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- E. Flexible Elastomeric: Closed cell or expanded rubber materials comply with ASTM C534, Type I for tubular materials and Type II for sheet materials.
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Aeroflex USA, Inc.; Aerocel.
    - b. Armacell, LLP; Armaflex.
    - c. RBX Corp.; Insul-Sheet 1800 and Insul Tube 180.
- F. Mineral-Fiber, Preformed Pipe Insulation:
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Fibrex Insulations Inc.; Coreplus 1200.
    - b. Johns Manville; Micro-Lok.
    - c. Knauf Insulation; 1000(Pipe Insulation.
    - d. Manson Insulation Inc.; Alley-K.
    - e. Owens Corning; Fiberglas Pipe Insulation.
  - 2. 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.
- G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" article.
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Cell-U-Foam Corp.; Ultra-CUF.
    - b. Pittsburgh Corning Corp.; FoamGlas Super K.
  - 2. Special Shaped Insulation: ASTM 552, Type III.



3. Preformed Pipe Insulation without Jacket: Comply with ASTM C552, Type II, Class 1.
4. Preformed Pipe Insulation with Factory-Applied Jacket: Comply with ASTM C552, Type II, Class 2.
5. Factory fabricate shades according to ASTM C450 and ASTM C585.

## **2.2 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. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class 1.
  1. Products: Subject to compliance with requirements, provide the following:
    - a. Aeroflex USA, Inc.; Aero seal.
    - b. Armacell, LLC; 520 Adhesive.
    - c. RBX Corp.; Rubatex Contact Adhesive.
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
  1. Products: Subject to compliance with requirements, provide the following:
    - a. Childers Products, Division of ITW; CP-82.
    - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
    - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
    - d. Marathon Industries, Inc.; 225.
    - e. Mon-Eco Industries, Inc.; 22-25.
- D. Cellular Glass Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 degrees F.
  1. Products: Subject to compliance with requirements, provide the following:
    - a. Childers Products, Division of ITW; CP-96.
    - b. Foster Products Corp.; H.B. Fuller Co.; 81-33.

## **2.3 MASTICS**

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
  1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Products, Division of ITW; CP-30.
    - b. Foster Products Corporation, H. B. Fuller Company; 30-35.

- c. ITW TACC, Division of Illinois Tool Works; CB-25.
  - d. Marathon Industries, Inc.; 501.
  - e. Mon-Eco Industries, Inc.; 55-10.
2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
  3. Service Temperature Range: 0 to 180 deg F.
  4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
  5. Color: White.

## **2.4 LAGGING ADHESIVES**

- A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Products, Division of ITW; CP-52.
    - b. Foster Products Corporation, H. B. Fuller Company; 81-42.
    - c. Marathon Industries, Inc.; 130.
    - d. Mon-Eco Industries, Inc.; 11-30.
    - e. Vimasco Corporation; 136.
  2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
  3. Service Temperature Range: Minus 50 to plus 180 deg F.
  4. Color: White.

## **2.5 SEALANTS**

- A. Joint Sealants:
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.

## **2.6 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.

3. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
  - a. Products: Subject to compliance with requirements, provide the following:
    - 1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
4. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
  - a. Products: Subject to compliance with requirements, provide the following:
    - 1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

## **2.7 FIELD-APPLIED FABRIC-REINFORCING MESH**

- A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch for covering pipe and pipe fittings.
  1. Products: Subject to compliance with requirements, provide the following:
    - a. Vimasco Corporation; Elastafab 894.
- B. Woven Glass-Fiber Fabric for Equipment Insulation: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. inch for covering equipment.
  1. Products: Subject to compliance with requirements, provide the following:
    - a. Childers Products, Division of ITW; Chil-Glas No. 5.

## **2.8 FIELD-APPLIED CLOTHS**

- A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.
  1. Products: Subject to compliance with requirements, provide the following:
    - a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

## **2.9 FIELD-APPLIED JACKETS**

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

- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Johns Manville; Zeston.
  - b. P.I.C. Plastics, Inc.; FG Series.
  - c. Proto PVC Corporation; LoSmoke.
  - d. Speedline Corporation; SmokeSafe.
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White Color-code jackets based on system or Color as selected by Architect.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
  - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
5. Factory-fabricated tank heads and tank side panels.

C. Metal Jacket:

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Childers Products, Division of ITW; Metal Jacketing Systems.
  - b. PABCO Metals Corporation; Surefit.
  - c. RPR Products, Inc.; Insul-Mate.
2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.
  - a. Factory cut and rolled to size.
  - 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. 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. Products: Subject to compliance with requirements, provide one of the following:
    - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
    - b. Compac Corp.; 104 and 105.
    - c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
    - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
  2. Width: 3 inches.
  3. Thickness: 11.5 mils.
  4. Adhesion: 90 ounces force/inch in width.
  5. Elongation: 2 percent.
  6. Tensile Strength: 40 lbf/inch in width.
  7. 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. Products: Subject to compliance with requirements, provide one of the following:
    - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
    - b. Compac Corp.; 130.
    - c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
    - d. Venture Tape; 1506 CW NS.
  2. Width: 2 inches.
  3. Thickness: 6 mils.
  4. Adhesion: 64 ounces force/inch in width.
  5. Elongation: 500 percent.
  6. Tensile Strength: 18 lbf/inch in width.
- C. PVDC Tape: White vapor-retarder PVDC tape with acrylic adhesive.
1. Products: Subject to compliance with requirements, provide the following:
    - a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.
  2. Width: 3 inches.
  3. Film Thickness: 4 mils.
  4. Adhesive Thickness: 1.5 mils.
  5. Elongation at Break: 145 percent.
  6. Tensile Strength: 55 lbf/inch in width.

## 2.11 SECUREMENTS

### A. Bands:

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Childers Products; Bands.
  - b. PABCO Metals Corporation; Bands.
  - c. RPR Products, Inc.; Bands.
2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing or closed seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing or closed seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

### B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
  - a. Products: Subject to compliance with requirements, provide one of the following:
    - 1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
    - 2) GEMCO; Perforated Base.
    - 3) Midwest Fasteners, Inc.; Spindle.
  - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
  - c. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
  - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
2. 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. Products: Subject to compliance with requirements, provide one of the following:
    - 1) AGM Industries, Inc.; RC-150.
    - 2) GEMCO; R-150.
    - 3) Midwest Fasteners, Inc.; WA-150.

- 4) Nelson Stud Welding; Speed Clips.
- b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
3. 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.
  - a. Products: Subject to compliance with requirements, provide one of the following:
    - 1) GEMCO.
    - 2) Midwest Fasteners, Inc.

## **2.12 CORNER ANGLES**

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

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

### **3.2 PREPARATION**

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

### **3.3 GENERAL INSTALLATION REQUIREMENTS**

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. 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 as recommended by insulation material manufacturer to maintain vapor seal.
  5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- 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.

### **3.4 PENETRATIONS**

- A. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- B. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems" for firestopping and fire-resistive joint sealers.
- C. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
  2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 7 Section "Firestopping"

### 3.5 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, vessels, and equipment. Shape insulation at these connections by tapering it to and around the

connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

- 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.

### **3.6 CELLULAR-GLASS INSULATION INSTALLATION**

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

### **3.7 MINERAL-FIBER INSULATION INSTALLATION**

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe 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.

C. 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.

### **3.8 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION**

- A. Seal longitudinal seams and end joints with manufacturers 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 pipe insulation.
  - 4. Secure insulation to flanges and seal seams with manufacturers 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 mitered sections of pipe insulation.
  - 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 preformed valve covers manufactured of same material as pipe insulation when available.
  - 2. When preformed 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.

### **3.9 FIELD-APPLIED JACKET INSTALLATION**

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
  - 1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
  - 2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
  - 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. 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.
- C. 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.
- D. Where PVDC jackets are indicated, install as follows:
  1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
  2. Wrap factory-presize jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presize jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
  3. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
  4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch- circumference limit allows for 2-inch- overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
  5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

### **3.10 FINISHES**

- A. Equipment and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 9 painting Sections.
  1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
    - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- C. Do not field paint aluminum or stainless-steel jackets.

### **3.11 FIELD QUALITY CONTROL**

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

- B. Perform tests and inspections.
- C. Tests and Inspections:
  - 1. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
  - 2. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

### **3.12 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. Pipe insulation exposed in return air plenums shall be noncombustible or shall be listed and labeled as having a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E 84 or UL 723.
- 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.

### **3.13 INDOOR PIPING INSULATION SCHEDULE: All Insulation to meet ASHRAE 90.1.**

- A. Domestic Cold Water:
  - 1. NPS 1-1/4 and Smaller: Insulation shall be the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
  - 2. NPS 1-1/2 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.
  - 2. NPS 1-1/2 and Larger: Insulation shall be the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1½ inch thick.
- C. 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. Flexible Elastomeric: 3/4 inch thick.
    - b. Polyolefin: 3/4 inch thick.

### **3.14 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. Equipment, Concealed:
  - 1. None.
- D. Piping, Exposed:
  - 1. PVC: 30 mils thick.
  - 2. Aluminum, Smooth: 0.032 inch thick.
  - 3. Painted Aluminum, Smooth: 0.032 inch thick.

**END OF SECTION 220719**



## **SECTION 221116 - 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 1 Specification Sections, apply to this Section.

#### **1.2 SUMMARY**

- A. This Section includes water distribution piping from locations indicated to fixtures and equipment inside building.

#### **1.3 DEFINITIONS**

- A. Water Service Piping: Water piping outside building that conveys water to building.
- B. Service Entrance Piping: Water piping at entry into building between water service piping and water distribution piping.
- C. Water Distribution Piping: Water piping inside building that conveys water to fixtures and equipment throughout the building.
- D. The following are industry abbreviations for plastic piping materials:
  - 1) CPVC: Chlorinated polyvinyl chloride.
  - 2) PVC: Polyvinyl chloride.

#### **1.4 SYSTEM PERFORMANCE REQUIREMENTS**

- A. Provide components and installation capable of producing piping systems with the following minimum working-pressure ratings, unless otherwise indicated:
  - 1) Combined Fire-Protection and Domestic, Service Entrance Piping: 200 psig.
  - 2) Service Entrance Piping: 150 psig.
  - 3) Water Distribution Piping: 150 psig.

#### **1.5 QUALITY ASSURANCE**

- A. Provide listing/approval stamp, label, or other marking on piping made to specified standards.

- B. Piping, fittings, and components shall meet NSF 61.

## **PART 2 - PRODUCTS**

### **2.1 COPPER TUBE AND FITTINGS**

- A. Hard Copper Tube: ASTM B 88, Type L and ASTM B 88, Type M water tube, drawn temper.
- B. Tube in "Soft Copper Tube" Paragraph below is available in NPS 1/8 to NPS 12 (DN 6 to DN 300).
- C. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.
- D. Fittings in "Cast-Copper, Solder-Joint Fittings" Paragraph below are available in NPS 1/4 to NPS 12 (DN 8 to DN 300).
- E. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
- F. Fittings in "Wrought-Copper, Solder-Joint Fittings" Paragraph below are available in NPS 1/4 to NPS 8 (DN 8 to DN 200).
- G. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
- H. Flanges in "Bronze Flanges" Paragraph below are available in NPS 1/2 to NPS 12 (DN 15 to DN 300).
- I. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
- J. Unions in "Copper Unions" Paragraph below are available in NPS 1/4 to NPS 4 (DN 8 to DN 100).
- K. 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.
- L. Copper Pressure-Seal-Joint Fittings:
  - 1) Fittings for NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber, O-ring seal in each end.
  - 2) Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Cast-bronze or wrought-copper fitting with EPDM-rubber, O-ring seal in each end.
- M. Copper Push-on-Joint Fittings:
  - 1) Description:

- a. Cast-copper fitting complying with ASME B16.18 or wrought-copper fitting complying with ASME B 16.22.
  - b. Stainless-steel teeth and EPDM-rubber, O-ring seal in each end instead of solder-joint ends.
- N. Appurtenances for Grooved-End Copper Tubing:
  - 1) Bronze Fittings for Grooved-End, Copper Tubing: ASTM B 75 (ASTM B 75M) copper tube or ASTM B 584 bronze castings.
  - 2) Mechanical Couplings for Grooved-End Copper Tubing:
    - a. Copper-tube dimensions and design similar to AWWA C606.
    - b. Ferrous housing sections.
    - c. EPDM-rubber gaskets suitable for hot and cold water.
    - d. Bolts and nuts.
    - e. Minimum Pressure Rating: 300 psig (2070 kPa).

## **2.2 JOINING MATERIALS**

- A. General: Applications of the following piping joining materials are indicated in Part 3 "Piping Applications" Article.
- B. Solder: ASTM B 32, Alloy Sn95; lead free.
- C. Transition Couplings: Coupling or other manufactured fitting same size as, with pressure rating at least equal to, and with ends compatible with piping to be joined.

## **PART 3 - EXECUTION**

### **3.1 PIPING APPLICATIONS**

- A. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below, unless otherwise indicated.
- B. Flanges may be used on aboveground piping, unless otherwise indicated.
- C. Aboveground, Water Distribution Piping Mains: Use the following:
  - 1) 2-Inch NPS and Smaller: Hard copper tube, Type L; copper, solder-joint fittings; and soldered joints, or Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); copper pressure-seal-joint fittings; and pressure-sealed joints.
  - 2) 2-1/2 to 4-Inch NPS: Hard copper tube, Type L; copper, solder-joint fittings; and soldered joints, or Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); copper pressure-seal-joint fittings; and pressure-sealed joints.
- D. Aboveground, Water Distribution Piping Branches (downstream of shut-off valves): Use the

following:

- 1) 2-Inch NPS and Smaller: Hard copper tube, Type L; copper, solder-joint fittings; and soldered joints, or Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); copper pressure-seal-joint fittings; and pressure-sealed joints.
  - 2) 2-1/2 to 4-Inch NPS: Hard copper tube, Type L; copper, solder-joint fittings; and soldered joints, or Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); copper pressure-seal-joint fittings; and pressure-sealed joints.
- E. Underground, Water Distribution Piping: Do not use flanges or valves underground. Use the following:
- 1) 2-Inch NPS and Smaller: Soft copper tube, Type K; wrought-copper, solder-joint pressure fittings; and soldered joints.
  - 2) 2-1/2- to 4-Inch NPS: Hard copper tube, Type K; wrought-copper, solder-joint pressure fittings; and soldered joints.

### **3.2 VALVE APPLICATIONS**

- 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 butterfly valves.
- B. Grooved-end butterfly valves may be used with grooved-end piping.

### **3.3 PIPING INSTALLATION, GENERAL**

- A. Refer to Division 22 Section "Basic Plumbing Requirements" for basic piping installation.

### **3.4 SERVICE ENTRANCE PIPING INSTALLATION**

- A. Extend service entrance piping to exterior water service piping in sizes and locations indicated for service entrances into building.
- B. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside building at each service entrance pipe.
- C. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service entrance pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Refer to Division 22 Section "Basic Mechanical Materials and Methods" for sleeves and mechanical sleeve seals.
- D. Install wall penetration system at each service entrance pipe penetration through foundation wall. Make installation watertight. Refer to Division 22 Section "Basic Mechanical Materials and Methods" for wall penetration systems.

### **3.5 WATER DISTRIBUTION PIPING INSTALLATION**

- A. Install piping with 0.25 percent slope downward toward drain.

### **3.6 JOINT CONSTRUCTION**

- A. Refer to Division 22 Section "Basic Plumbing Requirements" for basic piping joint construction.
- B. Grooved Joints: Assemble joints with coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

### **3.7 VALVE INSTALLATION**

- A. Sectional Valves: Install sectional valves close to main on each branch and riser serving plumbing fixtures or equipment, and where indicated. Use ball valves for piping 2-inch NPS and smaller. Use butterfly valves for piping 2-1/2-inch NPS and larger.
- B. Shutoff Valves: Install shutoff valve on each water supply to equipment, on each supply to plumbing fixtures without supply stops, and where indicated. Use ball valves for piping 2-inch NPS and smaller. Use butterfly valves for piping 2-1/2-inch NPS and larger.
- C. Drain Valves: Install drain valves for equipment, at base of each water riser, at low points in horizontal piping, and where required to drain water piping.
  - 1) Install hose-end drain valves at low points in water mains, risers, and branches.
- D. Balancing Valves: Install in each hot-water circulation return branch, discharge side of each pump and circulator, and where indicated.

### **3.8 HANGER AND SUPPORT INSTALATION**

- A. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.
- B. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.
  - 1) Vertical Piping: MSS Type 8 or 42, clamps.
  - 2) Individual, Straight, Horizontal Piping Runs:
    - a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    - b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
    - c. Longer Than 100 Feet (30 m) If Indicated: MSS Type 49, spring cushion rolls.
  - 3) Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
  - 4) Base of Vertical Piping: MSS Type 52, spring hangers.

- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch (10 mm).
- E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
  - 1) NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
  - 2) NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
  - 3) NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
  - 4) NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
  - 5) NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
  - 6) NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
  - 7) NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.
- F. Install supports for vertical copper tubing every 10 feet (3 m).
- G. Install hangers for galvanized steel piping with the following maximum horizontal spacing and minimum rod diameters:
  - 1) NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.
- H. Install supports for vertical steel piping every 15 feet (4.5 m).
- I. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

### **3.9 CONNECTIONS**

- A. Connect service entrance piping to exterior water service piping. Use transition fitting to join dissimilar piping materials.
- B. Connect water distribution piping to service entrance piping at shutoff valve, and extend to and connect to the following:
  - 1) Booster Systems: Connect cold-water suction and discharge piping.
  - 2) Water Heaters: Connect cold-water supply and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
  - 3) Plumbing Fixtures: Connect hot- and cold-water supply piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Plumbing Fixtures."
  - 4) Equipment: Connect hot- and cold-water supply piping as indicated. Provide shutoff valve and union for each connection. Use flanges instead of unions for connections 2-1/2-inch NPS and larger.

### **3.10 FIELD QUALITY CONTROL**

A. Inspect water distribution piping as follows:

1) Inspect service entrance piping and water distribution piping as follows:

- a. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- b. 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.
- c. Roughing-In Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
- d. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- e. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections, and arrange for reinspection.
- f. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

2) Test service entrance piping and water distribution piping as follows:

- a. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
- b. Leave uncovered and unconcealed new, altered, extended, or replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
- c. Cap and subject piping to static water pressure of 150 psig. Isolate test source and allow to stand for 4 hours. Leaks and loss in test pressure constitute defects that must be repaired.
- d. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
- e. Prepare reports for tests and required corrective action.

### 3.11 CLEANING

A. Clean and disinfect service entrance piping and water distribution piping as follows:

- 1) Purge new piping and parts of existing water piping that have been altered, extended, or repaired before using.
- 2) Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed, procedure described in either AWWA C651 or AWWA C652 or as 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 3 hours.
    - c. Flush system with clean, potable water until chlorine is no longer in water coming from system after the standing time.
    - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows contamination.
  - B. Prepare and submit reports for purging and disinfecting activities.
  - C. Clean interior of piping system. Remove dirt and debris as work progresses.

### **3.12 COMMISSIONING**

- A. Fill water piping. Check components to determine that they are not air bound and that piping is full of water.
- B. Perform the following steps before putting into operation:
- C. Close drain valves, hydrants, and hose bibbs.
  - 1) Open shutoff valves to fully open position.
  - 2) Set balancing valves to proper setting.
  - 3) Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
  - 4) Remove and clean strainer screens. Close drain valves and replace drain plugs.
  - 5) Remove filter cartridges from housings and verify that cartridges are as specified for application where used and that cartridges are clean and ready for use.
- D. Check plumbing equipment and verify proper settings, adjustments, and operation. Do not operate water heaters before filling with water.
- E. Check plumbing specialties and verify proper settings, adjustments, and operation.
  - 1) Water-Pressure Regulators: Set outlet pressure at 80 psig maximum, unless otherwise indicated.
- F. Energize pumps and verify proper operation.

**END OF SECTION 221116**



## **SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES**

### **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. Vacuum breakers.
2. Backflow preventers.
3. Balancing valves.
4. Temperature-actuated, water mixing valves.
5. Strainers for domestic water piping.
6. Outlet boxes.
7. Hose bibbs.
8. Wall hydrants.
9. Drain valves.
10. Water-hammer arresters.
11. Flexible connectors.

- B. Related Requirements:

1. Section 211100 "Facility Fire-Suppression Water-Service Piping" for fire water-service backflow prevention devices.
2. Section 220519 "Meters and Gauges for Plumbing Piping" for thermometers, pressure gauges, and flow meters in domestic water piping.
3. Section 221116 "Domestic Water Piping" for water meters.

#### **1.3 DEFINITIONS**

- A. AMI: Advanced Metering Infrastructure.
- B. AMR: Automatic Meter Reading.
- C. FKM: A family of fluoroelastomer materials defined by ASTM D1418.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For domestic water piping specialties.
  - 1. Include diagrams for power, signal, and control wiring.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Test and inspection reports.
- B. Field quality-control reports.

#### 1.6 CLOSEOUT SUBMITTALS

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

### PART 2 - PRODUCTS

#### 2.1 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.

#### 2.2 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: **125 psig (860 kPa)** unless otherwise indicated.

#### 2.3 VACUUM BREAKERS

- A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
  - 1. Standard: ASSE 1001.
  - 2. Size: **NPS 1/4 to NPS 3 (DN 8 to DN 80)**, as required to match connected piping.
  - 3. Body: Bronze.
  - 4. Inlet and Outlet Connections: Threaded.
  - 5. Finish: **Rough bronze**.

B. 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.
4. Finish: **Rough bronze**.

C. Pressure Vacuum Breakers:

1. Standard: ASSE 1020.
2. Operation: Continuous-pressure applications.
3. Pressure Loss: **5 psig (35 kPa)** maximum, through middle third of flow range.
4. Size: **1/2 NPS to 3 NPS (DN)**.
5. Accessories:
  - a. Valves: Ball type, on inlet and outlet.

## 2.4 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

1. See Plumbing Schedule sheet P6.00 for more information.
2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: **12 psig (83 kPa)** maximum, through middle third of flow range.
5. Size: ½ NPS to 3 NPS.
6. Design Flow Rate: See Plumbing Schedule sheet P6.00 for more information.
7. Body: **Bronze or stainless steel** for **NPS 2 (DN 50)** and smaller; **ductile or cast iron with interior lining that complies with AWWA C550 or that is FDA approved or stainless steel** for **NPS 2-1/2 (DN 65)** and larger.
8. End Connections: Threaded for **NPS 2 (DN 50)** and smaller; **flanged** for **NPS 2-1/2 (DN 65)** and larger.
9. Configuration: Designed for **horizontal, straight-through** flow.
10. Accessories:
  - a. Valves **NPS 2 (DN 50)** and Smaller: Ball type with threaded ends on inlet and outlet.
  - b. Valves **NPS 2-1/2 (DN 65)** 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.

B. Double-Check, Backflow-Prevention Assemblies:

1. See Plumbing Schedule sheet P6.00 for more information.
2. Standard: ASSE 1015.
3. Operation: Continuous-pressure applications unless otherwise indicated.
4. Pressure Loss: **5 psig (35 kPa)** maximum, through middle third of flow range.
5. Size: ½ NPS to 3 **NPS (DN)**.

6. Design Flow Rate: See Plumbing Schedule sheet P6.00 for more information.
7. Body: **Bronze or stainless steel** for **NPS 2 (DN 50)** and smaller; **ductile or cast iron with interior lining that complies with AWWA C550 or that is FDA approved or stainless steel** for **NPS 2-1/2 (DN 65)** and larger.
8. End Connections: Threaded for **NPS 2 (DN 50)** and smaller; **flanged** for **NPS 2-1/2 (DN 65)** and larger.
9. Configuration: Designed for **horizontal, straight-through** flow.
10. Accessories:
  - a. Valves **NPS 2 (DN 50)** and Smaller: Ball type with threaded ends on inlet and outlet.
  - b. Valves **NPS 2-1/2 (DN 65)** and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

C. Hose-Connection Backflow Preventers:

1. Standard: ASSE 1052.
2. Operation: Up to **10-foot head of water (30-kPa)** back pressure.
3. Inlet Size: **NPS 3/4 (DN 20)**.
4. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
5. Capacity: At least **3-gpm (0.19-L/s)** flow.

D. Backflow-Preventer Test Kits:

1. Description: Factory calibrated, with gauges, fittings, hoses, and carrying case with test-procedure instructions.

## 2.5 BALANCING VALVES

### SECTION INCLUDES

- A. Unit shall be a CircuitSolver® Thermostatic Balance Valve Models CS, CSU, CSUA, CSUAS, or CSUTD-D as manufactured by ThermOmegaTech.
- B. Furnish Thermostatic Balance Valve with capabilities as indicated in the plans and details.

### RELATED SECTIONS

- A. Section 22 11 00 – Facility Water Distribution
- B. Section 22 11 16 – Domestic Water Piping

## 1.03 REFERENCES

- A. ANSI - American National Standards Institute

B. ISO - International Standards Organization

C. NSF – National Science Foundation

#### **1.04 SUBMITTALS**

A. CS, CSU, CSUA, CSUAS, & CSUTD-D submittals

B. Technical Brochure

C. Dimensional prints

D. Sales Brochure

#### **1.05 QUALITY ASSURANCE**

A. The valve manufacturer shall be fully certified by the International Standards Organization per ISO 9001:2015.

A. The valve shall be NSF61 certified.

B. The valve shall carry a 3 year warranty.

#### **1.06 MAINTENANCE MATERIAL SUBMITTALS**

A. Installation & maintenance instruction manual

### **PART 2 PRODUCTS**

#### **2.01 MANUFACTURERS**

A. Subject to compliance with these specifications, the following manufacturers shall be acceptable:

1. Thermostatic Balance Valve

- a. ThermOmegaTech Inc. CircuitSolver® Models CS, CSU, CSUA, CSUAS, CSUTD-D as well as associated accessories such as Model CSA and CSUATD-D and models with optional thermometer, PEX ends or ProPress ends.
- a. Pre-approved equal.

#### **2.02 COMPONENTS**

A. Thermostatic Balance Valve

1. The valve shall be certified lead free according to NSF/ANSI 61 standards.
2. The valve body shall be constructed out of stainless steel.
3. The valve shall be rated for 200 PSIG working pressure and 250°F max. temperature.
4. The valve shall have a fixed, non-adjustable (tamper proof) temperature setpoint; temperature setpoints range from 80°F (27°C) to 170°F (27°C) in 5°F (2.8°C) increments.
5. The valve shall have a temperature accuracy of  $\pm 3.0^{\circ}\text{F}$  ( $\pm 1.7^{\circ}\text{C}$ ).
6. The valve shall have a wax thermostatic element.
7. The valve shall come in six sizes: 1/2"; 3/4"; 1"; 1 1/4"; 1 1/2"; 2".

## 2.02 ACCESSORIES

A. Thermostatic Balance Valve Accessories:

1. Model CS and CSU with optional thermometer, PEX ends or ProPress ends.
2. Model CSU, CSUA, CSUAS, CSUTD-D with integrated check valve.
3. Model CSUA and CSUAS with shutoff valves and optional thermometer, PEX ends or ProPress ends.

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. Install Thermostatic Balance Valve in accordance with manufacturer's instructions.
- B. Unit shall be a ThermOmegaTech CircuitSolver® thermostatic balancing valve Models CS, CSU, CSUA, CSUAS, CSUTD-D and associated assemblies CSA and CSUATD-D manufactured by ThermOmegaTech®, Warminster, PA.

## 2.6 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices:

1. Standard: ASSE 1070.
2. Pressure Rating: 125 psig (860 kPa).
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. Tempered-Water Setting: 105 deg F.
8. Valve Finish: Rough bronze.

B. Primary, Thermostatic, Water Mixing Valves:

1. Standard: ASSE 1017.
2. Pressure Rating: **125 psig (860 kPa)** 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. Tempered-Water Setting: 120 **deg F**.
8. Tempered-Water Design Flow Rate: See Plumbing Schedule sheet P6.00 for more information.
9. Selected Valve Flow Rate at **45-psig (310-kPa)** Pressure Drop: See Thermostatic Mixing Valve Schedule.
10. Pressure Drop at Design Flow Rate: See Thermostatic Mixing Valve Schedule.
11. Valve Finish: **Rough bronze**.
12. Piping Finish: **Copper**.

C. Individual-Fixture, Water Tempering Valves:

1. Manufacturers:
  - a. Leonard Valve Company
  - b. Zurn
  - c. Watts
  - d. Acorn
2. Standard: ASSE 1016, thermostatically controlled, water tempering valve.
3. Pressure Rating: **125 psig (860 kPa)** minimum unless otherwise indicated.
4. Material: Bronze body with corrosion-resistant interior components.
5. Temperature Control: Adjustable.
6. Connections: Threaded inlets and outlet.
7. Finish: Chrome plated.
8. Tempered-Water Setting: 105 **deg F**.
9. Tempered-Water Design Flow Rate: See Plumbing Schedule sheet P6.00 for more information.

## 2.7 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Manufacturers:
  - a. Watts
  - b. Zurn
  - c. Titan
2. Pressure Rating: **125 psig (860 kPa)** minimum unless otherwise indicated.
3. Body: Bronze for **NPS 2 (DN 50)** 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 (DN 65)** and larger.

4. End Connections: Threaded for **NPS 2 (DN 50)** and smaller; flanged for **NPS 2-1/2 (DN 65)** and larger.
5. Screen: Stainless steel with round perforations unless otherwise indicated.
6. Perforation Size:
  - a. Strainers **NPS 2 (DN 50)** and Smaller: **0.033 inch (0.84 mm)**.
  - b. Strainers **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)**: **0.062 inch (1.57 mm)**.
7. Drain: **Pipe plug**.

## 2.8 OUTLET BOXES

### A. Clothes Washer Outlet Boxes:

1. See Plumbing Schedule sheet P6.00 for more information.
2. Mounting: Recessed.
3. Material and Finish: **Enameled-steel, epoxy-painted-steel, or plastic** box and faceplate.
4. Faucet: Combination valved fitting or separate hot- and cold-water valved fittings complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.
5. Drain Outlet Connection: **NPS 2 (DN 50)**.
6. Accessory: Water hammer arresters.
7. Supply Shutoff Fittings: **NPS 1/2 (DN 15)** gate, globe, or ball valves and **NPS 1/2 (DN 15)** copper, water tubing.
8. Drain: **NPS 2 (DN 50)** standpipe and P-trap for direct waste connection to drainage piping.
9. Inlet Hoses: Two **60-inch- (1500-mm-)** long, rubber, household clothes washer inlet hoses with female, garden-hose-thread couplings. Include rubber washers.
10. Drain Hose: One **48-inch- (1200-mm-)** long, rubber, household clothes washer drain hose with hooked end.

## 2.9 HOSE BIBBS

### A. Hose Bibbs:

1. See Plumbing Schedule sheet P6.00 for more information.
2. Standard: ASME A112.18.1 for sediment faucets.
3. Body Material: Bronze.
4. Seat: Bronze, replaceable.
5. Supply Connections: **NPS 1/2 or NPS 3/4 (DN 15 or DN 20)** threaded or solder-joint inlet.
6. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
7. Pressure Rating: **125 psig (860 kPa)**.
8. Vacuum Breaker: Integral **or field-installation**, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
9. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
10. Finish for Service Areas: **Rough bronze, Chrome or nickel plated**.



11. Finish for Finished Rooms: Chrome or nickel plated.
12. Operation for Equipment Rooms: Wheel handle or operating key.
13. Operation for Service Areas: **Wheel handle**, or **Operating key**.
14. Operation for Finished Rooms: **Wheel handle**, or **Operating key**.
15. Include operating key with each operating-key hose bibb.
16. Include **integral** wall flange with each chrome- or nickel-plated hose bibb.

## 2.10 WALL HYDRANTS

### A. Non-freeze Wall Hydrants:

1. See Plumbing Schedule sheet P6.00 for more information.
2. Standard: ASME A112.21.3M for **concealed**, or **exposed**-outlet, self-draining wall hydrants.
3. Pressure Rating: **125 psig (860 kPa)**.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: **NPS 3/4 or NPS 1 (DN 20 or DN 25)**.
7. Outlet, Concealed: With integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounted with cover.
9. Box and Cover Finish: **Polished nickel bronze**, or **Rough bronze**.
10. Outlet, Exposed: With integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
11. Nozzle and Wall-Plate Finish: **Polished nickel bronze**, **Rough bronze**, or **Chrome plated**.
12. Operating Keys(s): **One** with each wall hydrant.

### B. Non-freeze Vacuum Breaker Wall Hydrants:

1. See Plumbing Schedule sheet P6.00 for more information.
2. Standard: ASSE 1019, Type A or Type B.
3. Type: Automatic draining with integral air-inlet valve.
4. Classification: Type B, for automatic draining with hose removed or with hose attached and nozzle closed.
5. Pressure Rating: **125 psig (860 kPa)**.
6. Operation: **Loose key**.
7. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
8. Inlet: **NPS 1/2 or NPS 3/4 (DN 15 or DN 20)**.
9. Outlet: Exposed with garden-hose thread complying with ASME B1.20.7.

## 2.11 DRAIN VALVES

### A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: **400-psig (2760-kPa)** minimum CWP.
3. Size: **NPS 3/4 (DN 20)**.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

B. Gate-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-80 for gate valves.
2. Pressure Rating: Class 125.
3. Size: **NPS 3/4 (DN 20)**.
4. Body: ASTM B62 bronze.
5. Inlet: **NPS 3/4 (DN 20)** threaded or solder joint.
6. Outlet: Garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

C. Stop-and-Waste Drain Valves:

1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: **200-psig (1380-kPa)** minimum CWP or Class 125.
3. Size: **NPS 3/4 (DN 20)**.
4. Body: Copper alloy or ASTM B62 bronze.
5. Drain: **NPS 1/8 (DN 6)** side outlet with cap.

## 2.12 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Standard: ASSE 1010 or PDI-WH 201.
2. Type: **Piston**.
3. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

## 2.13 FLEXIBLE CONNECTORS

A. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

1. Working-Pressure Rating: Minimum **200 psig (1380 kPa)**.
2. End Connections **NPS 2 (DN 50)** and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections **NPS 2-1/2 (DN 65)** and Larger: Flanged copper alloy.

- B. Stainless Steel-Hose Flexible Connectors: Corrugated-stainless steel tubing with stainless steel wire-braid covering and ends welded to inner tubing.
  - 1. Working-Pressure Rating: Minimum **200 psig (1380 kPa)**.
  - 2. End Connections **NPS 2 (DN 50)** and Smaller: Threaded steel-pipe nipple.
  - 3. End Connections **NPS 2-1/2 (DN 65)** and Larger: Flanged steel nipple.

## PART 3 - EXECUTION

### 3.1 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. Water Regulators: Install with inlet and outlet shutoff valves. Install pressure gauges on inlet and outlet.
- C. Water Control Valves: Install with inlet and outlet shutoff valves. Install pressure gauges on inlet and outlet.
- D. Automatic Water Shutoff Valves: Test for signal strength before valve installation. Install automatic shutoff valve downstream from main domestic water shutoff valve. Install valve controller in an accessible location with sensors in areas where water is likely to accumulate.
- E. Balancing Valves: Install in locations where they can easily be adjusted. Set at indicated design flow rates.
- F. Temperature-Actuated, Water Mixing Valves: Install with check stops or shutoff valves on inlets and with shutoff valve on outlet.
  - 1. Install cabinet-type units recessed in or surface mounted on wall as specified.
- G. Y-Pattern Strainers: For water, install on supply side of each **control valve, water pressure-reducing valve, solenoid valve, and pump**.
- H. Outlet Boxes: Install boxes recessed in wall or surface mounted on wall. Install **1-1/2-by-3-1/2-inch (38-by-89-mm)** fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 061000 "Rough Carpentry."

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

### **3.2 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.

### **3.3 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.

### **3.4 CONTROL CONNECTIONS**

- A. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

### **3.5 IDENTIFICATION**

- A. Plastic Labels for Equipment: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
  1. Vacuum breakers.
  2. Backflow preventers.
  3. Water pressure-reducing valves.
  4. Automatic water shutoff valve systems.
  5. Balancing valves.
  6. Temperature-actuated, water mixing valves.
  7. Outlet boxes.
  8. Hose stations.
  9. Wall hydrants.
- B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

### 3.6 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 **pressure vacuum breaker, reduced-pressure-principle backflow preventer double-check, backflow-prevention assembly, and double-check, detector-assembly backflow preventer** in accordance with manufacturer's written instructions, authorities having jurisdiction and the device's reference standard.

### 3.7 FIELD QUALITY CONTROL

- A. Testing Agency: **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 the following tests and inspections **with the assistance of a factory-authorized service representative**.
  - 1. Test each **pressure vacuum breaker, reduced-pressure-principle backflow preventer, double-check, backflow-prevention assembly and, double-check, detector-assembly backflow preventer** according to authorities having jurisdiction and the device's reference standard.
  - 2. Leak Test: After installation, charge system 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 unit operation.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

**END OF SECTION 221119**

## **SECTION 221316 - SANITARY WASTE AND VENT PIPING**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

#### **1.2 SUMMARY**

- A. This Section includes the following for soil, waste, and vent piping inside the building:
  - 1. Pipe, tube, and fittings.
  - 2. Special pipe fittings.
  - 3. Encasement for underground metal piping.

#### **1.3 DEFINITIONS**

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. EPDM: Ethylene-propylene-diene terpolymer rubber.
- C. LLDPE: Linear, low-density polyethylene plastic.
- D. NBR: Acrylonitrile-butadiene rubber.
- E. PE: Polyethylene plastic.
- F. PVC: Polyvinyl chloride plastic.
- G. TPE: Thermoplastic elastomer.

#### **1.4 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.

## **1.5 SUBMITTALS**

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Field quality-control inspection and test reports.

## **1.6 QUALITY ASSURANCE**

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

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

### **2.2 PIPING MATERIALS**

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.

### **2.3 PVC PIPE AND FITTINGS**

- A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
  - 1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.
- B. Solvent Cement and Adhesive Primer:
  - 1. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 2. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

### **2.4 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS**

- A. Pipe and Fittings: Shall conform to the requirements of CISPI 301, ASTM A 74, and shall bear the collective trademark of the Cast Iron Soil Pipe Institute and be listed by NSF International.

a. Manufacturers:

- 1) Charlotte Pipe
- 2) Tyler Pipe
- 3) ABI

B. Gaskets: ASTM C 564 and ASTM C 1563.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

## 2.5 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: Shall conform to the requirements of CISPI 301, ASTM A 888, and shall bear the collective trademark of the Cast Iron Soil Pipe Institute and be listed by NSF International.

a. Manufacturers:

- 1) Charlotte Pipe
- 2) Tyler Pipe
- 3) ABI

B. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

1. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, 4 stainless-steel bands and tightening devices, conforming to ASTM C 564 and ASTM C 1540.

a. Manufacturers:

- 1) ANACO.
- 2) Clamp-All Corp.
- 3) Ideal Div.; Stant Corp.
- 4) Mission Rubber Co.
- 5) Tyler Pipe; Soil Pipe Div.

2. Heavy-Duty, Shielded, Cast-Iron Couplings: ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve.

a. Manufacturers:

- 1) MG Piping Products Co.

C. Rigid, Unshielded Couplings: ASTM C 1461, sleeve-type, reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:



- a. ANACO.

## **2.6 SPECIAL PIPE FITTINGS**

- A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:

- a. Dallas Specialty & Mfg. Co.
- b. Fernco, Inc.
- c. Logan Clay Products Company (The).
- d. Mission Rubber Co.
- e. NDS, Inc.
- f. Plastic Oddities, Inc.

2. Sleeve Materials:

- a. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
- b. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
- c. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.

- B. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and 2 corrosion-resistant-metal tension band and tightening mechanisms on each end.

1. Manufacturers:

- a. Cascade Waterworks Mfg. Co.
- b. Mission Rubber Co.

- C. Rigid, Unshielded, Nonpressure Pipe Couplings: ASTM C 1461, sleeve-type reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with 2 corrosion-resistant-metal tension bands and tightening mechanisms on each end.

1. Manufacturers:

- a. ANACO.

## **PART 3 - EXECUTION**

### **3.1 EXCAVATION**

- A. Refer to Section 220512 for excavating, trenching, and backfilling.

### **3.2 PIPING APPLICATIONS**

- A. PVC pipe may be used in return air plenum ceilings if the pipe is wrapped with fire barrier wrap meeting ASTM E84 25/50 flame/smoke rating.
- B. Aboveground, soil and waste piping located in plenum spaces NPS 4 and smaller shall be the following:
  - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
  - 2. Hubless cast-iron soil pipe and fittings and heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
  - 3. Schedule 40 PVC pipe (piping in return air plenums must be wrapped with fire barrier wrap meeting ASTM E84 25/50 flame/smoke rating).
- C. Aboveground, vent piping NPS 4 and smaller shall be the following:
  - 1. Schedule 40 PVC. PVC pipe may be used in return air plenum ceilings if the pipe is wrapped with fire barrier wrap meeting ASTM E84 25/50 flame/smoke rating.
- D. Underground, soil, waste, and vent piping NPS 6 and smaller shall be the following:
  - 1. Schedule 40 PVC.

### **3.3 PIPING INSTALLATION**

- A. Basic piping installation requirements are specified in Division 22 Section "Basic Plumbing Requirements."
- B. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.
- C. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.
- D. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight.
- E. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
  - 1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.
- F. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and

reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

- G. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:
  - 1. Horizontal Sanitary Drain: 2 percent downward in direction of flow for piping NPS 2 and smaller; 1 percent downward in direction of flow for piping NPS 3 and larger.
  - 2. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- H. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- I. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.
- J. Install underground PVC soil and waste drainage piping according to ASTM D 2321.
- K. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

### **3.4 JOINT CONSTRUCTION**

- A. Basic piping joint construction requirements are specified in Division 15 Section "Basic Mechanical Materials and Methods."
- B. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- C. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

### **3.5 HANGER AND SUPPORT INSTALLATION**

- A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports." Install the following:
  - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
  - 2. Install individual, straight, horizontal piping runs according to the following:
    - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
  - 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. Install supports according to Division 22 Section "Hangers and Supports."

- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
  - 1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
  - 2. NPS 3: 60 inches with 1/2-inch rod.
  - 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
- F. Install supports for vertical cast-iron soil piping every 15 feet.
- G. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

### **3.6 CONNECTIONS**

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect drainage and vent piping to the following:
  - 1. Plumbing Fixtures: Connect drainage piping in sizes indicated, 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 drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
  - 4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

### **3.7 FIELD QUALITY CONTROL**

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
  - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
  - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
  - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
  - 2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
  - 3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
  - 4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
  - 5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
  - 6. Prepare reports for tests and required corrective action.

### **3.8 CLEANING**

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

**END OF SECTION 221316**

## **SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

#### **1.2 SUMMARY**

- A. This Section includes the following sanitary drainage piping specialties:
  - 1. Cleanouts.
  - 2. Floor drains.
  - 3. Floor sinks.
  - 4. Roof flashing assemblies.
  - 5. Through-penetration firestop assemblies.
  - 6. Miscellaneous sanitary drainage piping specialties.
  - 7. Flashing materials.

#### **1.3 SUBMITTALS**

- A. Field quality-control test reports.
- B. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

#### **1.4 QUALITY ASSURANCE**

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

#### **1.5 COORDINATION**

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
- B. Coordinate size and location of roof penetrations.

## **PART 2 - PRODUCTS**

### **2.1 CLEANOUTS**

#### **A. Metal Floor Cleanouts (FCO):**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
  - b. Tyler Pipe; Wade Div.
  - c. Zurn Plumbing Products Group; Light Commercial Operation.
  - d. Josam Company; Josam Div.
2. Standard: ASME A112.36.2M for heavy-duty, adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Heavy-duty, adjustable housing.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Required.
7. Outlet Connection: Spigot.
8. Closure: Brass plug with tapered threads.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Stainless steel and acid resistant epoxy coated in food preparation areas.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Extra-Heavy class, cast-iron drainage pipe fitting and riser to cleanout.
14. Standard: ASME A112.3.1.
15. Size: Same as connected branch.

#### **B. Wall Cleanouts (WCO):**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
  - b. Tyler Pipe; Wade Div.
  - c. Zurn Plumbing Products Group; Specification Drainage Operation.
  - d. Josam Company; Josam Div.
2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hub-and-spigot, cast-iron soil pipe T-branch as required to match connected piping.
5. Closure: Countersunk, drilled-and-threaded brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.

## **2.2 FLOOR DRAINS**

### **A. Floor Drains:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
  - b. Tyler Pipe; Wade Div.
  - c. Zurn Plumbing Products Group; Specification Drainage Operation.
  - d. Josam Company; Josam Div.
2. Standard: ASME A112.6.3.
3. Refer to schedule on plans.
4. Trap Material: Cast iron.
5. Trap Pattern: Deep-Seal P-trap.

### **B. Floor Sinks:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
  - b. Tyler Pipe; Wade Div.
  - c. Zurn Plumbing Products Group; Specification Drainage Operation.
  - d. Josam Company; Josam Div.
2. Standard: ASME A112.6.3.
3. Refer to schedule on plans.
4. Trap Material: Cast iron.
5. Trap Pattern: Deep-Seal P-trap.

## **2.3 ROOF FLASHING ASSEMBLIES**

### **A. Roof Flashing Assemblies:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Acorn Engineering Company; Elmdor/Stoneman Div.
  - b. Thaler Metal Industries Ltd.

### **B. Description: Manufactured assembly made of 4.0-lb/sq. ft., 0.0625-inch-thick, lead flashing collar and skirt extending at least 6 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.**

1. Open-Top Vent Cap: Without cap.
2. Extended Vent Cap: With field-installed, vandal-proof vent cap.



## **2.4 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES**

- A. Frost-Resistant Vent Terminals:
  - 1. Description: Manufactured or shop-fabricated assembly constructed of copper, lead-coated copper or galvanized steel.
  - 2. Design: To provide 1-inch enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.
- B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.
- C. Fasteners: Metal compatible with material and substrate being fastened.
- D. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- E. Solder: ASTM B 32, lead-free alloy.
- F. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
  - 1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
  - 2. Locate at each change in direction of piping greater than 45 degrees.
  - 3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
  - 4. Locate at base of each vertical soil and waste stack.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
  2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
    - a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
    - b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
    - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
  3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
  4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- F. Install through-penetration firestop assemblies in plastic conductors at floor penetrations.
- G. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- H. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
- I. Install wood-blocking reinforcement for wall-mounting-type specialties.
- J. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
- K. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

### **3.2 CONNECTIONS**

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

### **3.3 FLASHING INSTALLATION**

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
1. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
  2. Copper Sheets: Solder joints of copper sheets.

- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
  - 1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
  - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
  - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 7 Section "Sheet Metal Flashing and Trim."
- F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.
- G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

### **3.4 LABELING AND IDENTIFYING**

- A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

### **3.5 FIELD QUALITY CONTROL**

- A. Tests and Inspections:
  - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

### **3.6 PROTECTION**

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

## **END OF SECTION 221319**

## **SECTION 221429 - SUMP PUMPS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

**A. Section Includes:**

1. Sump pumps - submersible.
2. Oil-sensing sump pumps and controllers.
3. Sump-pump basins and basin covers.
4. Packaged drainage-pump units - submersible.

**B. Related Requirements:**

1. Section 221329 "Sanitary Sewerage Pumps" for effluent and sewage pumps.

#### **1.2 ACTION SUBMITTALS**

**A. Product Data:**

1. Sump pumps - submersible.
2. Oil-sensing sump pumps and controllers.
3. Sump-pump basins and basin covers.
4. Packaged drainage-pump units - submersible.

**B. Product Data Submittals: For each product.**

1. Construction details, material descriptions, dimensions of individual components and profiles.
2. Rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

**C. Shop Drawings:**

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.

#### **1.3 CLOSEOUT SUBMITTALS**

**A. Operation and Maintenance Data: For pumps and controls.**

1. Indicate actual installed items by marking submittals with an arrow or box.

#### **1.4 DELIVERY, STORAGE, AND HANDLING**

- A. Retain shipping flange protective covers and protective coatings during storage.
- B. Protect bearings and couplings against damage.
- C. Comply with manufacturer's written instructions for handling.

#### **1.5 WARRANTY**

- A. Manufacturer Warranty: Manufacturer and Installer agree to repair or replace sump pumps that fail in materials or workmanship within specified warranty period.
  1. Warranty Period: 3 year(s) from date of Substantial Completion.

### **PART 2 - PRODUCTS**

#### **2.1 SOURCE LIMITATIONS**

- A. Obtain each type of sump pump from single source from single manufacturer.

#### **2.2 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. UL Compliance: Comply with UL 778 for motor-operated water pumps.

#### **2.3 SUMP PUMPS - SUBMERSIBLE**

- A. Sump Pumps - Submersible, Fixed Position, Single Seal: .
  1. 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:
    - a. GRUNDFOS CBS Inc.
    - b. Liberty Pumps.
    - c. Zoeller Company.
  2. Description: Factory-assembled and -tested sump-pump unit.

3. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 14.1-14.2 and HI 14.3.
4. Pump Casing: Cast iron, with strainer inlet; legs that elevate pump to permit flow into impeller; and vertical discharge for piping connection.
5. Impeller: Statically and dynamically balanced, manufacturer's standard designed for clear wastewater handling, and keyed and secured to shaft.
6. Pump and Motor Shaft: Stainless steel or steel, with factory-sealed, grease-lubricated ball bearings.
7. Seal: Mechanical.
8. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
  - a. Motor Housing Fluid: Oil.
9. Capacities and Characteristics:
  - a. Unit Capacity: 10 **gpm**.
  - b. Number of Pumps: One.
  - c. Each Pump:
    - 1) Capacity: 10 **gpm (L/min.)**.
    - 2) Total Dynamic Head: 25 **feet (kPa)**.
    - 3) Speed: See Sump Pump schedule.
    - 4) Discharge Size: **1-1/2" NPS (DN)**.
    - 5) Electrical Characteristics:
      - a) Motor Horsepower: 1/2 hp.
      - b) Volts: 115 V ac.
      - c) Phases: Single.
      - d) Hertz: 60..
10. Controls, Rod-and-Float Type:
  - a. Enclosure: NEMA 250, Type 4X.
  - b. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
  - c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
  - d. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than **60 inches (1500 mm)**.
  - e. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120 V ac, with transformer and contacts for remote alarm bell.
11. Controls, Float- and Pressure-Switch Type:
  - a. Enclosure: NEMA 250, Type 4X; wall mounted.
  - b. Switch Type: Mechanical-float type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.

- c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
- d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120 V ac, with transformer and contacts for remote alarm bell.

12. Control-Interface Features:

- a. Remote Alarm Contacts: For remote alarm interface.
- b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
  - 1) On-off status of pump.
  - 2) Alarm status.

## 2.4 SUMP-PUMP BASINS AND BASIN COVERS

- A. Basins: Factory-fabricated, watertight, cylindrical, basin sump with top flange and sidewall openings for pipe connections.
  - 1. Material: Fiberglass.
  - 2. Reinforcement: Mounting plates for pumps, fittings, and accessories.
  - 3. Anchor Flange: Same material as or compatible with basin sump, cast in or attached to sump, and in location and of size required to anchor basin in concrete slab.
- B. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
  - 1. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.
- C. Capacities and Characteristics:
  - 1. Capacity: **370 gal. (L)**.
  - 2. Diameter: **24 inches (mm)**.
  - 3. Depth: **48 inches (mm)**.
  - 4. Inlet No. 1:
    - a. Drainage Pipe Size: 4".
    - b. Bottom of Sump to Centerline: **30 inches (mm)**.
    - c. Type: Hubbed outside.
  - 5. Sidewall Outlet:
    - a. Discharge Pipe Size: 1-1/2".
    - b. Bottom of Sump to Centerline: 40".
    - c. Type: Hubbed inside.

6. Cover Material: Cast iron or steel with bituminous coating.
7. Cover Diameter: 24", but not less than OD of basin top flange.
8. Manhole Required in Cover: No.
9. Vent Size: 2".

## **2.5 MOTORS**

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220500 "Common Work Results for Plumbing."
  1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- B. Motors for submersible pumps are to be hermetically sealed.

## **PART 3 - EXECUTION**

### **3.1 EARTHWORK**

- A. Excavation and filling are specified in Section 312000 "Earth Moving."

### **3.2 EXAMINATION**

- A. Examine roughing-in for plumbing piping to verify actual locations of storm drainage piping connections before sump-pump installation.

### **3.3 INSTALLATION**

- A. Pump Installation Standards: Comply with HI 14.4 for installation of sump pumps.
- B. Equipment Mounting:
  1. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- C. Wiring Method: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.



### **3.4 PIPING CONNECTIONS**

- A. Comply with requirements for piping specified in Section 221414 "Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance.

### **3.5 STARTUP SERVICE**

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.

### **3.6 ADJUSTING**

- A. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust control set points.

### **3.7 FIELD QUALITY CONTROL**

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test, inspect, and adjust components, assemblies, and equipment installations, including connections.
- C. Tests and inspections:
  - 1. Perform each visual and mechanical inspection.
  - 2. Leak Test: After installation, charge system 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.
  - 5. Pumps and controls will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

### **3.8 DEMONSTRATION**

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

General Headquarters Complex  
Renovations to Interior/Exterior & Install Emergency Generator  
Multiple Assets  
Jefferson City, MO

State Project Number: R2502-01

**END OF SECTION 221429**

## **SECTION 223100 - DOMESTIC WATER SOFTENERS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

A. Section Includes:

1. Water softeners.
2. Chemicals.
3. Water-testing sets.

#### **1.2 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 water softeners.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

#### **1.3 INFORMATIONAL SUBMITTALS**

A. Seismic Qualification Data: Certificates, for water softeners, 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.

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

#### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For water softeners to include in emergency, operation, and maintenance manuals.

#### **1.5 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. Salt for Brine Tanks: Furnish in same form as and at least four times original load, but not less than 500 (90.7) lb (kg). Deliver on pallets according to the following:
    - a. Food-Grade Pellet Salt: In 40- or 50- (18.1- or 22.7-) lb (kg) packages.
    - b. Plain Pellet Salt: In 40- or 50- (18.1- or 22.7-) lb (kg) packages.
  - 2. Store salt on raised platform where directed by Owner. Do not store in contact with concrete floor.

#### **1.6 COORDINATION**

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

#### **1.7 WARRANTY**

- A. Special Warranty: Manufacturer agrees to repair or replace components of water softeners that fail in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Structural failures of mineral and brine tanks.
    - b. Faulty operation of controls.
    - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
    - d. Attrition loss of resin exceeding 3 percent per year.
    - e. Mineral washed out of system during service run or backwashing period.
    - f. Effluent turbidity greater and color darker than incoming water.
    - g. Fouling of underdrain system, gravel, and resin with turbidity or by dirt, rust, or scale from water softener or soft water, while operating according to manufacturer's written operating instructions.
  - 2. Water Softeners, Warranty Period: From date of Substantial Completion.
    - a. Mineral Tanks: Five years.
    - b. Brine Tanks: 10 years.
    - c. Control Valve: One year(s).

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.
- B. Seismic Performance: Water softeners 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 from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
- C. Capacities and Characteristics:
  - 1. Water Analysis:
    - a. Hardness: 15 grains/gal. or ppm (mg/L).
    - b. Iron: 0 ppm (mg/L).
  - 2. Continuous Service Flow Rate: 65 gpm at 15-psig (L/s at 104-kPa) pressure drop.
  - 3. Peak Service Flow Rate: 85 gpm at 25-psig (L/s at 173-kPa) pressure drop.
  - 4. Water Meter Size: 4" NPS (DN).
  - 5. Manifold Pipe Size: 2" NPS (DN).
  - 6. Number of Mineral Tanks: Two.
  - 7. Mineral Quantity, Each Tank: 7 cu. ft. (cu. m).
  - 8. Mineral Exchange Capacity: 300,000 grains/cu. ft. per lb (kg/cu. m per kg) of salt.
  - 9. Electrical Characteristics:
    - a. Volts: 120 V.
    - b. Phases: 1.
    - c. Hertz: 60 Hz.
  - 10. Salt Capacity: 150 lb (kg).
  - 11. Floor Area Required: 20 sq. ft. (sq. m).
  - 12. Height Required: 84 inches (mm).

### 2.2 WATER SOFTENERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Culligan International Company.
  - 2. Marlo Incorporated.
  - 3. WATTS; A Watts Water Technologies Company.

B. Description: Factory-assembled, pressure-type water softener.

1. Configuration: Twin unit with single mineral tanks and one brine tank.
2. Mounting: On skids.
3. Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F (5 to at least 38 deg C).
4. Mineral Tanks, FRP: Pressure-vessel quality.
  - a. Construction: Non-ASME code.
  - b. Pressure Rating: 100 (690) psig (kPa) minimum.
  - c. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
  - d. Support Legs or Skirt: Constructed of structural steel, welded to tank.
  - e. Upper Distribution System: Single, point type, fabricated from galvanized-steel pipe and fittings.
  - f. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from nonmetallic pipe and fittings with individual, fine-slotted, nonclogging plastic strainers, and arranged for even flow distribution through resin bed.
  - g. Liner: PE, ABS, or other material suitable for potable water.
5. Mineral Tanks, Stainless Steel: Electric welded; pressure-vessel quality.
  - a. Seismic Requirements: Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
  - b. Construction: Non-ASME code.
  - c. Pressure Rating: 100 (690) psig (kPa) minimum.
  - d. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
  - e. Handholes: 4 inches (102 mm) round or 4 by 6 inches (102 by 152 mm) elliptical, in top head and lower sidewall of tanks 30 (762) inches (mm) and smaller in diameter.
  - f. Support Legs or Skirt: Constructed of structural steel, welded to tank before testing and labeling.
  - g. Finish:
    - 1) Hot-dip galvanized on exterior and interior of tank after fabrication unless tank is stainless steel.
    - 2) Exterior of tank spray-painted with rust-resistant prime coat, 2- to 3-mil (0.051- to 0.076-mm) dry film thickness. Interior sandblasted and lined with epoxy-polyamide coating, 8- to 10-mil (0.203- to 0.254-mm) dry film thickness.
  - h. Upper Distribution System: Single, point type, fabricated from galvanized-steel pipe and fittings.
  - i. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging PE strainers, and arranged for even flow distribution through resin bed.
  - j. Liner: PE, ABS, or other material suitable for potable water.

6. Controls, Automatic: 120 V; factory wired and factory mounted on unit.
  - a. Adjustable duration of various regeneration steps.
  - b. Push-button start and complete manual operation.
  - c. Electric time clock and switch for automatic operation except for manual return to service.
  - d. Sequence of Operation: Multiport pilot-control valve automatically pressure-actuates main operating valve through steps of regeneration.
  - e. Pointer on pilot-control valve shall indicate cycle of operation.
  - f. Includes means of manual operation of pilot-control valve if power fails.
7. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:
  - a. Slow opening and closing, nonslam operation.
  - b. Diaphragm guiding on full perimeter from fully open to fully closed.
  - c. Isolated, dissimilar metals within valve.
  - d. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
  - e. Sampling cocks for soft water.
  - f. Special tools are not required for service.
8. Flow Control: Automatic, to control backwash and flush rates over wide variations in operating pressure; does not require field adjustments.
  - a. Meter Control: Each mineral tank is equipped with signal-register-head water meter that produces electrical signal indicating need for regeneration on reaching hand-set total in gallons (liters). Signal will continue until reset.
  - b. Demand-Initiated Control:
    - 1) Each twin mineral-tank unit is equipped with automatic-reset-head water meter, in common outlet header, that electrically activates cycle controller to automatically regenerate one mineral tank at preset total in gallons (liters) and divert flow to other tank. Automatically repeats with other tank. Electrical lockout prevents simultaneous regeneration of both tanks.
9. Brine Tank: Combination measuring and wet-salt storing system.
  - a. Tank and Cover Material: Fiberglass, 3/16 inch (4.8 mm) thick; or molded PE, 3/8 inch (9.5 mm) thick.
  - b. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawal and freshwater refill.
  - c. Size: Large enough for at least four regenerations at full salting.
10. Factory-Installed Accessories:
  - a. Piping, valves, tubing, and drains.
  - b. Sampling cocks.
  - c. Main-operating-valve position indicators.

- d. Water meters.

## **2.3 CHEMICALS**

- A. Mineral: High-capacity, sulfonated-polystyrene, ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock.
  - 1. Exchange Capacity: 300,000 grains/cu. ft. (kg.cu. m) of calcium carbonate of resin when regenerated with 15 lb (6.8 kg) of salt.
- B. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are unacceptable.
  - 1. Form: Processed, food-grade salt pellets.

## **2.4 WATER-TESTING SETS**

- A. Description: Manufacturer's standard water-hardness testing apparatus and chemicals with testing procedure instructions. Include metal container suitable for wall mounting.

## **2.5 SOURCE QUALITY CONTROL**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. ASME Compliance for FRP Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, where indicated.
- C. UL Compliance: Fabricate and label water softeners to comply with UL 979, "Water Treatment Appliances."
- D. Hydrostatically test mineral tanks before shipment to a minimum of one and one-half times the pressure rating.
- E. Prepare test and inspection reports.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION OF WATER SOFTENERS**

- A. Equipment Mounting:
  - 1. Install water softeners 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. Comply with requirements for vibration isolation and seismic-control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
  3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."
- B. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure.
- C. Install brine lines and fittings furnished by equipment manufacturer, but not specified to be factory installed.
- D. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.
- E. Install water-testing sets mounted on wall, unless otherwise indicated, and near water softeners.

### **3.2 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 equipment, allow space for service and maintenance.
- C. Install shutoff valves on raw-water inlet and soft-water outlet piping of each mineral tank, and on inlet and outlet headers.
1. Metal general-duty valves are specified in Section 220523 "General-Duty Valves for Plumbing Piping."
  2. Plastic valves are specified in Section 221116 "Domestic Water Piping."
  3. Exception for water softeners with factory-installed shutoff valves at locations indicated.
- D. Install pressure gauges on raw-water inlet and soft-water outlet piping of each mineral tank. Pressure gauges are specified in Section 220500 "Common Work Results for Plumbing."
1. Exception for water softeners with factory-installed pressure gauges at locations indicated.
- E. Install valved bypass in water piping around water softeners.
1. Metal general-duty valves are specified in Section 220523 "General-Duty Valves for Plumbing Piping."
  2. Plastic valves are specified in Section 221116 "Domestic Water Piping."
  3. Water piping is specified in Section 221116 "Domestic Water Piping."
- F. Install indirect wastes to spill into open drains or pit with drain.

### **3.3 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.

### **3.4 IDENTIFICATION**

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

### **3.5 FIELD QUALITY CONTROL**

- A. Testing Agency:
  - 1. 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 unit operation.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Water softeners will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

### **3.6 STARTUP SERVICE**

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
- B. Add water to brine tanks and fill with the following form of salt:

1. Water Softeners: Processed, plain salt pellets.
- C. Sample water softener effluent after startup and at three consecutive seven-day intervals (total of four samples), and prepare certified test reports for required water performance characteristics. Comply with the following:
  1. ASTM D859, "Test Method for Silica in Water."
  2. ASTM D1067, "Test Methods for Acidity or Alkalinity of Water."
  3. ASTM D1068, "Test Methods for Iron in Water."
  4. ASTM D1126, "Test Method for Hardness in Water."
  5. ASTM D1129, "Terminology Relating to Water."
  6. ASTM D3370, "Practices for Sampling Water from Closed Conduits."

### **3.7 DEMONSTRATION**

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain domestic water softeners.

**END OF SECTION 223100**

## **SECTION 223400 - FUEL-FIRED, DOMESTIC-WATER HEATERS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Gas-fired, tankless, domestic-water heaters.
  - 2. Domestic-water heater accessories.

#### **1.2 ACTION SUBMITTALS**

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
  - 1. Include diagrams for power, signal, and control wiring.

#### **1.3 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. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranty: For special warranty.

#### **1.4 CLOSEOUT SUBMITTALS**

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

#### **1.5 COORDINATION**

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

#### **1.6 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. Gas-Fired, Tankless, Domestic-Water Heaters:
      - 1) Heat Exchanger: Five years.
      - 2) Controls and Other Components: Three years.
    - b. Expansion Tanks: Five years.

### **PART 2 - PRODUCTS**

#### **2.1 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.
  - 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.
- C. ASHRAE/IES Compliance: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IES 90.1.

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.

## 2.2 GAS-FIRED, TANKLESS, DOMESTIC-WATER HEATERS

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. A. O. Smith Corporation.
2. Bradford White Corporation.
3. State Water Heaters.
4. Lochinvar.

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 (1035 kPa).
3. Heat Exchanger: Stainless steel.
4. Insulation: Comply with ASHRAE/IES 90.1.
5. Jacket: Metal, with enameled finish, or plastic.
6. Burner: For use with tankless, domestic-water heaters and natural-gas fuel.
7. Automatic Ignition: Manufacturer's proprietary system for automatic, gas ignition.
8. Temperature Control: Adjustable thermostat.

## 2.3 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Expansion Tanks:

1. 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:

- a. AMTROL, Inc.
  - b. ProFlo; a Ferguson Enterprises, Inc. brand.
  - c. Taco Comfort Solutions.
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: 150 psig.
  - b. Capacity Acceptable: 15 gallon minimum.
  - c. Air Precharge Pressure: 55 psig.
- 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 (DN 20) 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 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 2-psig (13.8-kPa) 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.
- 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.
- L. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.

## **2.4 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**

### **3.1 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 (450-mm) 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.
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. 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."
- D. 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."
- E. 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."
- F. 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".
- G. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend 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 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.
- I. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for 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."
- J. Install thermometer on outlet piping of 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 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."
- L. Install piping-type heat traps on inlet and outlet piping of domestic-water heater storage tanks without integral or fitting-type heat traps.
- M. Fill domestic-water heaters with water.
- N. Charge domestic-water expansion tanks with air to required system pressure.
- O. 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.

### **3.2 PIPING CONNECTIONS**

- A. Comply with requirements for domestic-water piping specified in Section 221116 "Domestic Water Piping."
- B. Comply with requirements for gas piping specified in Section 231123 "Facility Natural-Gas Piping."
- C. Drawings indicate general arrangement of piping, fittings, and specialties.
- D. 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.

### **3.3 IDENTIFICATION**

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

### **3.4 FIELD QUALITY CONTROL**

- A. Testing Agency:
  - 1. 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.

### **3.5 DEMONSTRATION**

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain gas-fired, tankless domestic-water heaters. Training shall be a minimum of one hour(s).

**END OF SECTION 223400**

## **SECTION 224100 - RESIDENTIAL PLUMBING FIXTURES**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

**A. Section Includes:**

1. Lavatories - wall mounted.
2. Lavatory faucets.
3. Showers - standard.
4. Showers - accessible.
5. Shower faucets.
6. Kitchen sinks.
7. Laundry trays.
8. Sink faucets.
9. Water closets.
10. Toilet seats.
11. Supply fittings.
12. Waste fittings.
13. Grout.

**B. Related Requirements:**

1. Section 224700 "Water Coolers."

#### **1.2 DEFINITIONS**

- A. FRP:** Fiberglass-reinforced plastic.
- B. PMMA:** Polymethyl methacrylate, also known as "acrylic."

#### **1.3 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 lavatories.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

**B. Shop Drawings:** Include diagrams for power, signal, and control wiring.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted plumbing fixtures.
- B. Sample Warranty: For special warranty.

#### **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For plumbing fixtures and faucets to include in emergency, operation, and operation and maintenance manuals.

#### **1.6 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
  - 2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.
  - 3. Flushometer-Tank Repair Kits: Equal to 5 percent of amount of each type installed, but no fewer than two of each type.
  - 4. Toilet Seats: Equal to 5 percent of amount of each type installed.

#### **1.7 WARRANTY**

- 1. Warranty Period for Residential Applications of Shells: Five years from date of Substantial Completion.
- 2. Warranty Period for Residential Applications of Pumps and Blowers: Five years from date of Substantial Completion.
- 3. Warranty Period for Residential Applications of Electronic Controls: Five years from date of Substantial Completion.

### **PART 2 - PRODUCTS**

#### **2.1 GENERAL REQUIREMENTS**

- A. Domestic water faucets 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.

## **2.2 LAVATORIES - WALL MOUNTED**

A. Vitreous-China Lavatories:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. American Standard.
  - b. Kohler Co.
  - c. TOTO USA, INC.

B. Fixture:

1. Standard:
  - a. ASME A112.19.2/CSA B45.1 for vitreous-china lavatories.
2. Type: Self-rimming.
3. Oval Nominal Size: 19 by 16 inches (483 by 406 mm).
4. Faucet-Hole Punching: Three holes, 4-inch (102-mm) centers.
5. Faucet-Hole Location: Rim.
6. Color: White.

C. Supply Fittings: Comply with requirements in "Supply Fittings" Article.

D. Waste Fittings: Comply with requirements in "Waste Fittings" Article.

## **2.3 LAVATORY FAUCETS**

A. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.

B. General-Duty, Solid-Brass Lavatory Faucets:

1. 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:
  - a. American Standard.
  - b. Chicago Faucets; Geberit Group.
  - c. Delta Faucet Company.
  - d. Moen Incorporated.
  - e. TOTO USA, INC.

C. Description: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.

D. Standard: ASME A112.18.1/CSA B125.1.

- E. Body Material: General duty, solid brass.
- F. Finish: Polished chrome plate.
- G. Maximum Flow Rate: 1.2 gpm (9.5 L/min.).
- H. Centers: 4 inches (102 mm).
- I. Mounting: Deck, exposed.
- J. Valve Handle(s): Wrist blade, 4 inches (102 mm).
- K. Inlet(s): NPS 3/8 (DN 10) tubing, with NPS 1/2 (DN 15) male adaptor.
- L. Spout: Rigid.
- M. Spout Outlet: Aerator.
- N. Operation: Compression, manual.
- O. Drain: Grid.

## **2.4 SHOWERS - STANDARD**

- A. Shower by Arch. Coordinate with Architectural Drawings
- B. Standard: IAPMO Z124.1.2/ANSI Z124.1.2.
- C. Nominal Size: 32 inches x 44 inches.
- D. Surround:
  - 1. One piece or sealed, multiple piece.
- E. Bathing Surface: Slip resistant.
- F. Color: White.
- G. Drain Location: Center.

## **2.5 SHOWERS - ACCESSIBLE**

- A. Shower by Arch. Coordinate with Architectural drawings.
- B. Standards: IAPMO Z124.1.2/ANSI Z124.1.2 and ICC/ANSI A117.1 for roll-in shower compartments.
- C. Nominal Size: 65 by 36 inches

- D. Surround:
  - 1. One piece or sealed, multiple piece.
- E. Bathing Surface: Slip resistant.
- F. Color: White.
- G. Drain Location: Center.
- H. Accessibility Options: Grab bar and bench.
- I. Drain: Grid, NPS 2 (DN 50).

## **2.6 SHOWER FAUCETS**

- A. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.
- B. Single-Handle, Pressure-Balance Faucets:
  - 1. 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:
    - a. American Standard.
    - b. Moen Incorporated.
    - c. Symmons Industries, Inc.
    - d. T&S Brass and Bronze Works, Inc.
- C. Fixture:
  - 1. Description: Include hot- and cold-water indicators, check stops, and fixed showerhead, arm, and flange or ADA handheld head complying with ASSE 1014 with arm, flange, hose, and bracket. Coordinate faucet inlets with supplies.
  - 2. Standard: ASME A112.18.1/CSA B125.1.
  - 3. Body Material: Solid brass with nonmetallic trim.
  - 4. Finish: Polished chrome plate.
  - 5. Maximum Flow Rate: 2.5 gpm (9.5 L/min.) unless otherwise indicated.
  - 6. Mounting: Exposed.
  - 7. Backflow-Prevention Device for Handheld Shower: Required.
  - 8. Operation: Compression, manual.
  - 9. Antiscald Device: Integral with mixing valve.
  - 10. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
- D. Supply Connections: NPS 1/2 (DN 15).



E. Shower Head:

1. Type: Ball joint and head integral with mounting flange.
2. Shower Head Material: Nonmetallic with chrome-plated finish.
3. Spray Pattern: Fixed.
4. Integral Volume Control: Required.
5. Shower-Arm, Flow-Control Fitting: 1.75 GPM.

F. Shower Head – ADA:

1. Type: Handheld, slide-bar mounted.
2. Shower Head Material: Nonmetallic with chrome-plated finish.
3. Spray Pattern: Adjustable.
4. Integral Volume Control: Required.
5. Shower-Arm, Flow-Control Fitting: 1.75 gpm.

## 2.7 KITCHEN SINKS

A. Stainless Steel Kitchen Sink, Counter Mounted:

1. 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:
  - a. American Standard.
  - b. Elkay.
  - c. ProFlo; a Ferguson Enterprises, Inc. brand.

B. Fixture:

1. ASME A112.19.3/CSA B45.4 for stainless steel kitchen sinks.
2. Overall Dimensions: 18 inches by 18 inches.
3. Metal Thickness: 0.050 inch (1.3 mm).
4. Bowl:
  - a. Dimensions: 15 inches x 12 inches.
  - b. Drain: 3-1/2-inch (89-mm) grid.
    - 1) Location: Near back of bowl.

C. Supply Fittings: Comply with requirements in "Supply Fittings" Article.

D. Waste Fittings: Comply with requirements in "Waste Fittings" Article, except include continuous waste for multibowl sinks.

1. Disposer: Not required.
2. Hot-Water Dispenser: Not required.

## **2.8 SINK FAUCETS**

- A. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.
- B. General-Duty, Solid-Brass Sink Faucets:
  - 1. 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:
    - a. American Standard.
    - b. Chicago Faucets; Geberit Group.
    - c. Delta Faucet Company.
    - d. Moen Incorporated.

## **2.9 WATER CLOSETS**

- A. Water Closets: Floor mounted, floor outlet, flush valve, vitreous china, 1.6 gal./flush (6 L)/flush).
  - 1. 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:
    - a. American Standard.
    - b. Kohler Co.
    - c. TOTO USA, INC.
  - 2. Bowl:
    - a. Standards: ASME A112.19.2/CSA B45.1, ASME A112.19.5/CSA B45.15, and ASSE 1037/ASME A112.1060/CSA B125.16.
    - b. Bowl Type: Siphon jet.
    - c. Height: Standard or Handicapped/elderly.
    - d. Rim Contour: Elongated.
    - e. Color: White.
  - 3. Supply Fittings:
    - a. Standard: ASME A112.18.1/CSA B125.1.
    - b. Supply Piping: Chrome-plated-brass pipe or chrome-plated-copper tube matching water-supply piping size. Include chrome-plated wall flange.

## **2.10 TOILET SEATS**

- A. Toilet Seats:

1. 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:
  - a. American Standard.
  - b. Bemis Manufacturing Company.
  - c. Zurn Industries, LLC.
2. Standard: IAPMO Z124.5/ANSI Z124.5.
3. Material: Plastic.
4. Type: Commercial (Standard).
5. Shape: Elongated rim (Open front).
6. Configuration: Open front without cover.
7. Size: Elongated.
8. Hinge Type: Self-sustaining, check.
9. Hinge Material: Noncorroding metal.
10. Seat Cover: Not required.
11. Color: White.

## **2.11 SUPPLY FITTINGS**

- A. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.
- B. Standard: ASME A112.18.1/CSA B125.1.

## **2.12 WASTE FITTINGS**

- A. Standard: ASME A112.18.2/CSA B125.2.
- B. Drain:
  1. Grid type with NPS 1-1/4 (DN 32) offset tailpiece for accessible lavatories.
  2. Grid type with NPS 1-1/2 (DN 40) straight tailpiece for standard kitchen sinks.
- C. Trap:
  1. Size:
    - a. NPS 1-1/4 (DN 32) for lavatories.
    - b. NPS 1-1/2 (DN 40) for kitchen sinks.
  2. Material:
    - a. Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-(0.83-mm-) thick brass tube to wall; and chrome-plated-brass or -steel wall flange.

## **2.13 GROUT**

- A. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000 psi (34.5 MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine roughing-in of water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing-fixture installation.
- B. Examine walls, floors, cabinets, and counters for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION OF RESIDENTIAL PLUMBING FIXTURES**

- A. Install plumbing fixtures level and plumb in accordance with roughing-in drawings.
- B. Install floor-mounted water closets on closet flange attachments to drainage piping.
- C. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
  - 1. Use ball or gate valves if supply stops are not specified with fixture. Comply with valve requirements specified in Section 220523 "General-Duty Valves for Plumbing Piping."
- D. Install flush valves for accessible, flush valve-type water closets with lever handle mounted on wide side of compartment.
- E. Install toilet seats on water closets.
- F. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- G. Install shower flow-control fittings with specified maximum flow rates in shower arms.
- H. Install traps on fixture outlets.
  - 1. Omit trap on fixtures with integral traps.
  - 2. Omit trap on indirect wastes unless otherwise indicated.

- I. Set shower receptors in leveling bed of cement grout.
- J. 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."
- K. 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."
- L. Seal joints between plumbing fixtures, 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."

### **3.3 PIPING CONNECTIONS**

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste 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 lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

### **3.4 ADJUSTING**

- A. Operate and adjust plumbing fixtures and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.

### **3.5 CLEANING AND PROTECTION**

- A. After completing installation of plumbing fixtures, inspect and repair damaged finishes.
- B. Clean plumbing fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed plumbing fixtures and fittings.
- D. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

General Headquarters Complex  
Renovations to Interior/Exterior & Install Emergency Generator  
Multiple Assets  
Jefferson City, MO

State Project Number: R2502-01

**END OF SECTION 224100**

## **SECTION 224700 - WATER COOLERS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

**A. Section Includes:**

1. Water coolers.
2. Bottle filling stations.
3. Remote water coolers.
4. Fixture carriers.

#### **1.2 ACTION SUBMITTALS**

**A. Product Data:**

1. For each type of product.
  - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  - b. Include operating characteristics, and furnished specialties and accessories.

**B. Shop Drawings:**

1. Include plans, elevations, sections, and mounting details.
2. Include details of fixture 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 wiring.

**C. Delegated Design Submittals:** For vibration isolation and supports, , and seismic restraints indicated to comply with performance requirements and design criteria, including analysis data.

#### **1.3 INFORMATIONAL SUBMITTALS**

**A. Seismic Qualification Certificates:** For remote water coolers, 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.

#### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For drinking fountains, water coolers, bottle filling stations, to include in maintenance manuals.
  1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include servicing and adjustment of electronic-sensor fixtures.

#### **1.5 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. Filter Cartridges: Equal to 100 percent of quantity installed for each type and size indicated, but no fewer than 1 of each.

#### **1.6 DELIVERY, STORAGE, AND HANDLING**

- A. Comply with manufacturer's written instructions for delivery, storage, and handling.

#### **1.7 WARRANTY**

- A. Manufacturer Warranty: Manufacturer agrees to repair or replace drinking fountains, water coolers, or bottle filling stations that fail in materials or workmanship within specified warranty period.
  1. Failures include, but are not limited to, the following:
    - a. Faulty operation.
    - b. Deterioration of metals, metal finishes, and other materials beyond normal use.
- B. Warranty Period: One year(s) from date of Substantial Completion.

### **PART 2 - PRODUCTS**

#### **2.1 PERFORMANCE REQUIREMENTS**

- A. Standards:
  1. Drinking fountains, water coolers, bottle filling stations, and remote water coolers intended to convey or dispense water for human consumption are to comply with the U.S.



Safe Drinking Water Act (SDWA), requirements of the authority having jurisdiction, and with NSF 61 or NSF 372, or be certified in compliance with NSF 61 or NSF 372 by an 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. Delegated Design:

1. Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

## 2.2 WATER COOLERS

A. Water Coolers - Surface Wall Mounted, Stainless Steel:

1. 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:
  - a. Elkay.
  - b. Halsey Taylor.
  - c. Murdock Manufacturing; A Division of Morris Group International.
  - d. Oasis International.
2. Source Limitations: Obtain surface wall-mounted, stainless steel, water coolers from single source from single manufacturer.
3. Standards:
  - a. NSF 61.
  - b. NSF 372.
  - c. ASME A112.19.3/CSA B45.4.
  - d. ASHRAE 18.
  - e. UL 399.
  - f. 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.
4. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
5. Control: Push bar.
6. Bottle Filler: Sensor activation 20-second automatic shutoff timer: Fill rate is 0.5 to 1.5 gpm (0.03155 to 0.09464 L/s).
7. Drain: Grid with NPS 1-1/4 (DN 32) tailpiece.
8. Supply: NPS 3/8 (DN 10) with shutoff valve.
9. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 (DN 32) brass P-trap.
10. Filter: One or more water filters with capacity sized for unit peak flow rate.
  - a. Standards:

- 1) NSF 42.
- 2) NSF 53.
11. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
12. Support: Fixture carrier.
13. Water-Cooler Mounting Height: Accessible in accordance with ICC A117.1.
14. Capacities and Characteristics:
  - a. Cooled Water: 8 gph (0.0084 L/s).
  - b. Ambient-Air Temperature: 90 deg F (32 deg C).
  - c. Cooled-Water Temperature: 50 deg F (10 deg C).
  - d. Cooled-Water Storage: 50°F.
  - e. Electrical Characteristics:
    - 1) Motor Horsepower: 1/5.
    - 2) Volts: 120 V ac.
    - 3) Phase: Single.
    - 4) Hertz: 60 Hz.
    - 5) Full-Load Amperes: 5 A.
    - 6) Minimum Circuit Ampacity: 5 A.
    - 7) Maximum Overcurrent Protection: 15 A.

B. Water Coolers - Surface Wall Mounted, Powder-Coated Metal:

1. 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:
  - a. Elkay.
  - b. Murdock Manufacturing; A Division of Morris Group International.
  - c. Oasis International.
2. Source Limitations: Obtain surface wall-mounted, powder-coated-metal, water coolers from single source from single manufacturer.
3. Standards:
  - a. NSF 61.
  - b. NSF 372.
  - c. ASHRAE 18.
  - d. UL 399.
  - e. 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.
4. Color: Gray.
5. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
6. Control: Push bar.

7. Bottle Filler: Sensor activation, with 20-second automatic shutoff timer: Fill rate is 0.5 to 1.5 gpm (0.03155 to 0.09464 L/s).
8. Drain: Grid with NPS 1-1/4 (DN 32) tailpiece.
9. Supply: NPS 3/8 (DN 10) with shutoff valve.
10. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 (DN 32) brass P-trap.
11. Filter: One or more water filters with capacity sized for unit peak flow rate.
  - a. Standards:
    - 1) NSF 42.
    - 2) NSF 53.
12. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
13. Support: Fixture carrier.
14. Water-Cooler Mounting Height: Accessible in accordance with ICC A117.1.
15. Capacities and Characteristics:
  - a. Cooled Water: 8 gph (0.0084 L/s).
  - b. Ambient-Air Temperature: 90 deg F (32 deg C).
  - c. Cooled-Water Temperature: 50 deg F (10 deg C).
  - d. Cooled-Water Storage: 50.
  - e. Electrical Characteristics:
    - 1) Motor Horsepower: 1/5.
    - 2) Volts: 120 V ac.
    - 3) Phase: Single.
    - 4) Hertz: 60 Hz.
    - 5) Full-Load Amperes: 5 A.
    - 6) Minimum Circuit Ampacity: 5 A.
    - 7) Maximum Overcurrent Protection: 15 A.

## 2.3 BOTTLE FILLING STATIONS

### A. Bottle Filling Station - Surface Wall Mounted, Stainless Steel:

1. 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:
  - a. Elkay.
  - b. Halsey Taylor.
  - c. Murdock Manufacturing; A Division of Morris Group International.
  - d. Oasis International.
2. Source Limitations: Obtain surface wall-mounted, stainless steel, bottle filling stations from single source from single manufacturer.

3. Standards:
  - a. NSF 61.
  - b. NSF 372.
  - c. ASME A112.19.3/CSA B45.4.
4. Cabinet: Stainless steel.
5. Bottle Filler: Sensor activation, with 20-second automatic shutoff timer. Fill rate is 0.5 to 1.5 gpm (0.03155 to 0.09464 L/s).
6. Drain: Grid type with NPS 1-1/4 (DN 32) tailpiece.
7. Supply: NPS 3/8 (DN 10) with shutoff valve.
8. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 (DN 32) brass P-trap.
9. Cooling System: Electric, with precooler, hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
  - a. Standards:
    - 1) ASHRAE 18.
    - 2) UL 399.
    - 3) 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.
10. Ventilation Grille: Stainless steel, located below bottle filler.
11. Cooling System Capacities and Characteristics:
  - a. Cooled Water: 8 gph (0.0084 L/s).
  - b. Ambient-Air Temperature: 90 deg F (32 deg C).
  - c. Inlet-Water Temperature: 80 deg F (27 deg C).
  - d. Cooled-Water Temperature: 50 deg F (10 deg C).
  - e. Cooled-Water Storage: 50 deg F.
  - f. Electrical Characteristics:
    - 1) Motor Horsepower: 1/5.
    - 2) Volts: 120 V ac.
    - 3) Phase: Single.
    - 4) Hertz: 60 Hz.
    - 5) Full-Load Amperes: 5 A.
    - 6) Minimum Circuit Ampacity: 5 A.
    - 7) Maximum Overcurrent Protection: 15 A.
12. Filter: One or more water filters with capacity sized for unit peak flow rate.
  - a. Standards:
    - 1) NSF 42.
    - 2) NSF 53.

13. Support: Provide manufacturer's mounting plate.
14. Bottle Filling Station Mounting Height: Accessible in accordance with ICC A117.1.
15. Electrical Characteristics:
  - 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. Volts: 120 V ac.
  - c. Phase: Single.
  - d. Hertz: 60 Hz.

## **2.4 FIXTURE CARRIERS**

### **A. Fixture Carriers:**

1. 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:
  - a. Jay R. Smith Mfg Co; a division of Morris Group International.
  - b. MIFAB, Inc.
  - c. WATTS; A Watts Water Technologies Company.
  - d. Zurn Industries, LLC.
2. Standard: ASME A112.6.1M.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.
- B. Examine walls and floors for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Install fixtures level and plumb in accordance with roughing-in drawings. For fixtures indicated for juveniles, install at height required by authorities having jurisdiction.
- B. Set pedestal drinking fountains and bottle filling stations on flat surface in accordance with manufacturer's written installation instructions.
- C. Set freestanding water coolers on floor.

- D. Install recessed drinking fountains and bottle filling stations secured to wood blocking in wall construction.
- E. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.
- F. Install mounting frames, affixed to building construction, and attach recessed water coolers and bottle filling stations to mounting frames.
- G. Set remote water coolers on floor unless otherwise indicated.
  - 1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
  - 2. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."
- H. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 220523 "General-Duty Valves for Plumbing Piping."
- I. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
- J. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 "Common Work Results for Plumbing."
- K. Seal joints between fixtures 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."

### **3.3 PIPING CONNECTIONS**

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Install ball shutoff valve on water supply to each fixture.. Install valve upstream from filter for drinking fountain, water cooler, and bottle filling station. Comply with valve requirements specified in Section 220523 "General-Duty Valves for Plumbing Piping."
- D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

### **3.4 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. Nameplates to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

### **3.5 ADJUSTING**

- A. Adjust fixture flow regulators for proper flow and stream height.
- B. Adjust water cooler temperature settings.
- C. Adjust electronic-sensor settings.

### **3.6 CLEANING**

- A. After installing fixtures, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean fixtures, on completion of installation, in accordance with manufacturer's written instructions.
- C. Provide protective covering for installed fixtures.
- D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

**END OF SECTION 224700**

## **SECTION 230500 - COMMON WORK RESULTS FOR HVAC**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

**A. Section Includes:**

1. Motors.
2. Sleeves without waterstop.
3. Sleeves with waterstop.
4. Stack-sleeve fittings.
5. Sleeve-seal systems.
6. Grout.
7. Escutcheons.
8. Thermometers, bimetallic actuated.
9. Thermometers, filled system.
10. Thermometers, liquid in glass.
11. Duct-thermometer mounting brackets.
12. Thermowells.
13. Pressure gauges, dial type.
14. Gauge attachments.
15. Test plugs.
16. Sight flow indicators.

#### **1.2 DEFINITIONS**

- A. Existing Piping To Remain:** Existing piping that is not to be removed and that is not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

#### **1.3 ACTION SUBMITTALS**

**A. Product Data:**

1. For each type of product, excluding motors which are included in Part 1 of HVAC equipment Sections.
  - a. Include construction details, material descriptions, and dimensions of individual components, and finishes.
  - b. Include operating characteristics and furnished accessories.

- B. Delegated Design Submittals:** For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.



1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Product Certificates: For each type of meter.
- B. Field quality-control reports.

#### **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For each type of expansion joint, meter, and gauge to include in operation and maintenance manuals.

#### **1.6 QUALITY ASSURANCE**

- A. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.

#### **1.7 COORDINATION**

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
  1. Motor controllers.
  2. Torque, speed, and horsepower requirements of the load.
  3. Ratings and characteristics of supply circuit and required control sequence.
  4. Ambient and environmental conditions of installation location.

### **PART 2 - PRODUCTS**

#### **2.1 MOTORS**

- A. Motor Requirements, General:
  1. Content includes motors for use on alternating-current power systems of up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturers for field installation.

2. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or Sections.
3. Comply with NEMA MG 1 unless otherwise indicated.
4. Comply with IEEE 841 for severe-duty motors.

B. Motor Characteristics:

1. Duty: Continuous duty at ambient temperature of 104 deg F and at altitude of 750 ft. above sea level.
2. 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.

C. Polyphase Motors:

1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Premium Efficient, as defined in NEMA MG 1.
3. Service Factor: 1.15.
4. Rotor: Random-wound, squirrel cage.
5. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
6. Temperature Rise: Match insulation rating.
7. Insulation: Class F.

D. Additional Requirements for Polyphase Motors:

1. Motors Used with Variable-Frequency Controllers:
  - a. 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.
  - b. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
  - c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
  - d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

E. Electronically Commutated Motors:

1. Microprocessor-Based Electronic Control Module: Converts 120 V single-phase AC power to three-phase DC power to operate the brushless DC motor.
2. Three-phase power motor module with permanent magnet rotor.
3. Circuit board.
4. Building Automation System Interface: Via DC voltage signal.

## 2.2 SLEEVES AND SLEEVE SEALS

A. Sleeves without Waterstop:

1. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.
- B. Sleeves with Waterstop:
  1. Description: Manufactured steel, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.
- C. Stack-Sleeve Fittings:
  1. Description: Manufactured, 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.
- D. Sleeve-Seal Systems:
  1. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
    - a. Hydrostatic seal: 20 psig .
    - b. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
    - c. Pressure Plates: Carbon steel.
    - d. Connecting Bolts and Nuts: Carbon steel, with zinc coating. ASTM B633 of length required to secure pressure plates to sealing elements.
- E. Grout:
  1. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.
  2. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
  3. Design Mix: 5000 psi, 28-day compressive strength.
  4. Packaging: Premixed and factory packaged.

## **2.3 ESCUTCHEONS**

- A. Escutcheon Types:
  1. One-Piece, Stainless-steel Type: With polished stainless-steel finish.

## **2.4 METERS AND GAUGES FOR HVAC PIPING**

- A. Thermometers, Bimetallic Actuated:
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Palmer Wahl Instrumentation Group.
    - b. Trerice, H. O. Co.
    - c. Weiss Instruments, Inc.
    - d. WIKA Instrument Corporation.
  2. Source Limitations: Provide bimetallic-actuated thermometers from a single manufacturer.
  3. Standard: ASME B40.200.
  4. Case: Liquid-filled type(s); stainless-steel with 5-inch nominal diameter.
  5. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F.
  6. Connector Type(s): Union joint, rigid, bottom, with unified-inch screw threads.
  7. Connector Size: 1/2 inch, with ASME B1.1 screw threads.
  8. Stem: 0.25 or 0.375 inch in diameter; stainless-steel.
  9. Window: Plain glass.
  10. Ring: Stainless-steel.
  11. Element: Bimetal coil.
  12. Pointer: Dark-colored metal.
  13. Accuracy: Plus or minus 1 percent of scale range.
- B. Thermometers, Filled System - Direct-Mounted, Metal-Case, Vapor-Actuated:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Palmer Wahl Instrumentation Group.
    - b. Trerice, H. O. Co.
    - c. Weiss Instruments, Inc.
  2. Source Limitations: Provide filled-system, direct-mounted, metal-case, vapor-actuated thermometers from a single manufacturer.
  3. Standard: ASME B40.200.
  4. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
  5. Element: Bourdon tube or other type of pressure element.
  6. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
  7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
  8. Pointer: Dark-colored metal.
  9. Window: Glass.
  10. Ring: Stainless-steel.
  11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
    - a. Design for Air-Duct Installation: With ventilated shroud.
    - b. Design for Thermowell Installation: Bare stem.
  12. Accuracy: Plus or minus 1 percent of scale range.

C. Thermometers, Liquid in Glass - Metal Case, Industrial Style:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Palmer Wahl Instrumentation Group.
  - b. Terrice, H. O. Co.
  - c. Weiss Instruments, Inc.
2. Source Limitations: Provide liquid-in-glass, metal-case, industrial-style thermometers from single manufacturer.
3. Standard: ASME B40.200.
4. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.
5. Case Form: Straight unless otherwise indicated.
6. Tube: Glass with magnifying lens and blue or red organic liquid.
7. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
8. Window: Glass.
9. Stem: Aluminum and of length to suit installation.
  - a. Design for Air-Duct Installation: With ventilated shroud.
  - b. Design for Thermowell Installation: Bare stem.
10. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
11. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

D. Duct-Thermometer Mounting Brackets:

1. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

E. 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: CUNI.
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, 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.

F. Pressure Gauges, Dial Type - Direct Mounted, Metal Case:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Palmer Wahl Instrumentation Group.
  - b. Trerice, H. O. Co.
  - c. Weiss Instruments, Inc.
  - d. WIKA Instrument Corporation.
2. Source Limitations: Provide dial-type, direct-mounted, metal-case pressure gauges from single manufacturer.
3. Standard: ASME B40.100.
4. Case: Liquid-filled Solid-front, pressure-relief type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
5. Pressure-Element Assembly: Bourdon tube.
6. 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.
7. Movement: Mechanical, with link to pressure element and connection to pointer.
8. Dial: Nonreflective aluminum with permanent scale markings graduated in psi.
9. Pointer: Dark-colored metal.
10. Window: Safety glass.
11. Ring: Stainless-steel.
12. Accuracy: Grade B, plus or minus 2 percent of middle half of span.

G. Pressure Gauges, Dial Type - Remote Mounted, Metal Case:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Palmer Wahl Instrumentation Group.
  - b. Trerice, H. O. Co.
  - c. Weiss Instruments, Inc.
  - d. WIKA Instrument Corporation.
2. Source Limitations: Provide dial-type, remote-mounted, metal-case pressure gauges from a single manufacturer.
3. Standard: ASME B40.100.
4. Case: Liquid-filled type; cast aluminum or drawn steel; 4-1/2-inch nominal diameter with back flange and holes for panel mounting.
5. Pressure-Element Assembly: Bourdon tube.
6. 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.
7. Movement: Mechanical, with link to pressure element and connection to pointer.
8. Dial: Nonreflective aluminum with permanent scale markings graduated in psi.
9. Pointer: Dark-colored metal.
10. Window: Safety glass.
11. Ring: Stainless-steel.
12. Accuracy: Grade B, plus or minus 2 percent of middle half of span.

H. Gauge Attachments:

1. 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.
2. Siphons: Loop-shaped section of brass stainless-steel pipe with NPS 1/4 or NPS 1/2 pipe threads.
3. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

I. Test Plugs:

1. Source Limitations: Provide test plugs from single manufacturer.
2. Description: Test-station fitting made for insertion in piping tee fitting.
3. Body: Brass or stainless-steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
4. Thread Size: NPS 1/2, ASME B1.20.1 pipe thread.
5. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
6. Core Inserts: EPDM self-sealing rubber.

J. Sight Flow Indicators:

1. Source Limitations: Provide sight flow indicators from single manufacturer.
2. Description: Piping inline-installation device for visual verification of flow.
3. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.
4. Minimum Pressure Rating: 150 psig.
5. Minimum Temperature Rating: 200 deg F.
6. End Connections for NPS 2 and Smaller: Threaded.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION OF EXPANSION JOINTS - GENERAL**

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.

### **3.2 INSTALLATION OF PIPE LOOPS AND SWING CONNECTIONS**

- A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
- B. Connect risers and branch connections to mains with at least pipe fittings, including tee in main.
- C. Connect risers and branch connections to terminal units with at least pipe fittings, including tee in riser.

- D. Connect mains and branch connections to terminal units with at least pipe fittings, including tee in main.

### **3.3 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, seal space outside of sleeves in floors/slabs/walls without sleeve-seal system. Select to maintain fire resistance of floor/slab/wall.
- 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 that joint sealant manufacturer's literature indicates is 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."

### **3.4 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 centered across width of concrete slab or wall.



- C. Secure nailing flanges to wooden concrete forms.
- D. Using grout, seal space around outside of sleeves.

### **3.5 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 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."

### **3.6 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. 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.

### **3.7 INSTALLATION OF ESCUTCHEONS**

- 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.

### **3.8 INSTALLATION OF METERS AND GAUGES**

- A. Install thermowells with socket extending one-third of pipe diameter 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 remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing, and support tubing to prevent kinks. Use minimum tubing length.
- G. Install pipe-mounted thermal-energy temperature sensors in thermowells and extend wiring to indicator.
- H. Install duct-thermometer-mounting brackets in walls of ducts. Attach to duct with screws.
- I. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at the most readable position.
- J. Install remote-mounted pressure gauges on panel.
- K. Install valve and snubber in piping for each pressure gauge for fluids.
- L. Condensate
- M. Install test plugs in piping tees.
- N. Install flow indicators in piping systems in accessible positions for easy viewing.
- O. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.
- P. Install flowmeter elements in accessible positions in piping systems.
- Q. Install wafer-orifice flowmeter elements between orifice-type pipe flanges.
- R. Install all flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.
- S. Install permanent indicators on walls or brackets in accessible and readable positions.
- T. Install connection fittings in accessible locations for attachment to portable indicators.
- U. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.
- V. Install thermometers in the following locations:
  - 1. Inlet and outlet of each hydronic boiler.
  - 2. Two inlets and two outlets of each chiller.

3. Inlet and outlet of each hydronic coil in air-handling units.

W. Install pressure gauges in the following locations:

1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
3. Inlet and outlet of each hydronic boiler.
4. Suction and discharge of each pump.

### **3.9 CONNECTIONS**

- A. Install meters and gauges adjacent to machines and equipment to allow space for service and maintenance of meters, gauges, machines, and equipment.
- B. Connect flowmeter-system elements to meters.
- C. Connect flowmeter transmitters to meters.
- D. Connect thermal-energy meter transmitters to meters.

### **3.10 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.

### **3.11 FIELD QUALITY CONTROL**

- A. Sleeves and Sleeve Seals:
  1. Perform the following tests and inspections:
    - a. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
    - b. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.
  2. Prepare test and inspection reports.
- B. Escutcheons:
  1. Using new materials, replace broken and damaged escutcheons and floor plates.

### **3.12 SLEEVES APPLICATION**

- 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 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 annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs above Grade:
  - a. stack-sleeve fittings.
4. Interior Walls and Partitions:
  - a. Sleeves without waterstops.

### **3.13 ESCUTCHEONS APPLICATION**

- A. Escutcheons for New Piping and Relocated Existing Piping:
  1. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
  2. Chrome-Plated Piping: One piece, steel with polished, chrome-plated finish.
  3. Insulated Piping:
    - a. One piece, steel with finish.
    - b. One piece, stainless-steel with polished stainless-steel finish.
    - c. One piece, cast brass with finish.
    - d. One-piece, stamped steel with polished, chrome-plated finish.
  4. Bare Piping at Wall and Floor Penetrations in Finished Spaces:
    - a. One piece, steel with finish.
    - b. One piece, stainless-steel with polished stainless-steel finish.
    - c. One piece, cast brass with finish.
    - d. One-piece, stamped steel with polished, chrome-plated finish.
  5. Bare Piping at Ceiling Penetrations in Finished Spaces:
    - a. One piece, steel with finish.
    - b. One piece, stainless-steel with polished stainless-steel finish.
    - c. One piece, cast brass with finish.
    - d. One-piece, stamped steel with polished, chrome-plated finish.

- B. Escutcheons for Existing Piping to Remain:
  - 1. Chrome-Plated Piping: Split plate, stamped steel with hinge with polished, chrome-plated finish.
  - 2. Insulated Piping: Split plate, stamped steel with hinge with polished, chrome-plated finish.
  - 3. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split plate, stamped steel with hinge with polished, chrome-plated finish.
  - 4. Bare Piping at Ceiling Penetrations in Finished Spaces: Split plate, stamped steel with 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 and Relocated Existing Piping: Split floor plate.
  - 2. Existing Piping to Remain: Split floor plate.

### **3.14 THERMOMETER APPLICATION**

- A. Thermometers at inlet and outlet of each hydronic zone are to be the following:
  - 1. Liquid-filled, bimetallic-actuated type.
- B. Thermometers at inlet and outlet of each hydronic boiler are to be the following:
  - 1. Liquid-filled, bimetallic-actuated type.
- C. Thermometers at inlets and outlets of each chiller are to be the following:
  - 1. Liquid-filled, bimetallic-actuated type.
- D. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems are to be the following:
  - 1. Liquid-filled, bimetallic-actuated type.
- E. Thermometers at inlet and outlet of each hydronic heat-recovery unit are to be the following:
  - 1. Liquid-filled, bimetallic-actuated type.
- F. Thermometers at outside-, return-, supply-, and mixed-air ducts are to be the following:
  - 1. Liquid-filled, bimetallic-actuated type.
- G. Thermometer stems are to be of length to match thermowell insertion length.

**3.15 THERMOMETER SCALE-RANGE APPLICATION**

- A. Scale Range for Chilled-Water Piping:
  - 1. 0 to 250 deg F.
- B. Scale Range for Condenser-Water Piping:
  - 1. 0 to 150 deg F.
- C. Scale Range for Heating, Hot-Water Piping:
  - 1. 0 to 250 deg F.
- D. Scale Range for Air Ducts:
  - 1. Minus 40 to plus 110 deg F.

**3.16 PRESSURE-GAUGE SCALE-RANGE APPLICATION**

- A. Scale Range for Chilled-Water Piping:
  - 1. 0 to 100 psi.
- B. Scale Range for Condenser-Water Piping:
  - 1. 0 to 100 psi.
- C. Scale Range for Heating, Hot-Water Piping:
  - 1. 0 to 100 psi.

**3.17 THERMAL-ENERGY METER APPLICATION**

- A. Thermal-Energy Meters: Ultrasonic type.

**END OF SECTION**

## **SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

A. Section Includes:

1. Pipe hangers and supports - carbon steel.
2. Pipe/tube hangers and supports - copper.
3. Pipe hangers - metal, trapeze type.
4. Strut support system - metal, rod type.
5. Strut support system - metal, cable type.
6. Fastener system - mechanical expansion anchors.
7. Equipment supports.
8. Equipment stands - outdoor type.

#### **1.2 ACTION SUBMITTALS**

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.
2. Metal strut support systems.
3. Pipe stands.
4. Equipment supports.

C. Delegated Design Submittals: For trapeze hangers and strut support systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication/assembly and design calculations for trapeze hangers and strut support systems.
2. Detail fabrication/assembly and design calculations for each type of strut support system, by the manufacturer's technical representative.

#### **1.3 INFORMATIONAL SUBMITTALS**

A. Welding certificates.

## **1.4 QUALITY ASSURANCE**

- A. Structural-Steel Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators in accordance with 2021 ASME Boiler and Pressure Vessel Code, Section IX.

## **PART 2 - PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS**

- A. Structural Performance: Hangers and supports for HVAC piping and equipment are to withstand the effects of gravity loads and stresses within limits and under conditions indicated in accordance with 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.
  - 3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.
  - 4. See architectural / structural drawings for seismic design requirements.

### **2.2 PIPE HANGERS AND SUPPORTS - METAL**

- A. Pipe Hangers and Supports - Carbon Steel:
  - 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 washers made of carbon steel.
- B. Pipe/Tube Hangers and Supports - Copper:
  - 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.



## **2.3 PIPE HANGERS - METAL, TRAPEZE TYPE**

- 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.

## **2.4 STRUT SUPPORT SYSTEMS - METAL**

- A. Strut Support System - Metal, Rod Type:

1. Description: Factory-fabricated pipe-support assembly made of steel channels, vertical metal support rods, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Struts: Continuous slotted carbon-steel channel with intumed lips angle.
4. Strut Width: Selected for applicable load criteria.
5. Strut 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 stainless steel.
7. Metallic Coating: Hot-dip galvanized.

- B. Strut Support System - Metal, Cable Type:

1. Description: Factory-fabricated pipe-support system, consisting of cable pipe clamps and associated vibration isolation rubber pads, slotted channel brackets, wire rope suspension components, and associated accessories for a complete piping suspension system; no tools required for manual assembly in the field to support multiple parallel pipe routing.
2. Standards:
  - a. ICC-ES PMG Product Certificate.
  - b. Brackets: Fire-rated, tested to F120 in accordance with BS EN 1363-1:2020.
3. Components:
  - a. Pipe Clamps: Size-adjustable standard clamps with sleeves to prevent galvanic corrosion.
  - b. Brackets: Slotted galvanized (G90) steel channels furnished in pre-cut lengths to suit specific system application for Project.
  - c. Suspension Components: Hanging cables with adjustable fastener; can be pre-installed on the brackets using pre-fitted washer/nuts or retention clips.
    - 1) Wire Rope: High tensile steel wire rope, complying with ASTM A1023/A1023M, ASTM A641/A641M Class A zinc coating; cross-sectional construction; having a tensile strength of 256,000 psi; lengths, diameters, and wire construction to accommodate design loads.
      - a) Locking screw/release button.

- b) Foot attachment type to suit application.
- c) End Fix Type: as required to suit application.

## **2.5 FASTENER SYSTEMS**

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

- 1. Indoor Applications: Zinc-plated steel.

## **2.6 EQUIPMENT SUPPORTS**

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

## **2.7 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**

### **3.1 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 static loads within specified loading limits. Minimum static design load used for strength determination is to include weight of supported components plus 200 lb.

### **3.2 INSTALLATION OF HANGERS AND SUPPORTS**

- A. 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.
- B. Install lateral bracing with pipe hangers and supports to prevent swaying.
- C. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2 and larger and at changes in direction of piping. Coordinate location of concrete inserts before concrete is placed.
- D. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- E. 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.
- F. 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. Thermal hanger shield inserts may be used as an option. 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 are to span an arc of 180 degrees.
    - a. Thermal hanger shield inserts may be used as an option. 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.
- G. 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.
- H. 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 in accordance with ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel in accordance with AWS D1.1/D1.1M.
- I. FRP Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.
- J. Strut System Installation: Metal, rod type. Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems. Install in accordance with manufacturer's written installation instructions.
- K. Thermal Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- L. Fastener System Installation:
1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick after concrete is placed and cured. Use installers that are trained and certified by power tool manufacturer and in accordance with the AHJ.
  2. Install mechanical-expansion anchors after concrete is placed and completely cured.
  3. Install fasteners in accordance with manufacturer's written instructions.
  4. Install lag screw wood fasteners in accordance with manufacturer's written instructions.
- M. 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.
- N. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

- O. Equipment Support Installation:
  - 1. Fabricate from welded-structural-steel shapes.
  - 2. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
  - 3. Grouting: Place grout under supports for floor-mounted equipment, and make bearing surface smooth.
  - 4. Provide lateral bracing, to prevent swaying.

### **3.3 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.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; 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.

### **3.4 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.

### **3.5 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 a minimum dry film thickness of 2.0 mils.

2. Comply with requirements in Section 099113 "Exterior Painting for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
3. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

### **3.6 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, metal trapeze pipe hangers, 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. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3.
  8. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.

9. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
  10. 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.
  11. 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.
  12. 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.
  13. 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.
  14. 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.
  15. 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.
  16. 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.
  17. 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. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
  3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
  4. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
  5. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
  6. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
  7. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
  8. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
  9. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
  10. 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.
  11. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
  12. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
  13. 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 manufacturers 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. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

**END OF SECTION**

## **SECTION 230533 - HEAT TRACING FOR HVAC PIPING**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section includes heat tracing for freeze prevention of HVAC piping with self-regulating, parallel-resistance, electric heating cables:

#### **1.2 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
  - 2. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.
- B. Shop Drawings: For electric heating cable.
  - 1. Include plans, elevations, sections, and attachment details.
  - 2. Include diagrams for power, signal, and control wiring.

#### **1.3 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For electric heating cables and controls to include in operation and maintenance manuals.

#### **1.4 WARRANTY**

- A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Five years from date of Substantial Completion.

### **PART 2 - PRODUCTS**

#### **2.1 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES**

- A. Source Limitations: Obtain all heat tracing from one manufacturer.
- B. Standard: IEEE 515.1.

- C. Heating Element: Pair of parallel No. 16 AWG, tinned, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length.
- D. Electrical Insulating Jacket: Flame-retardant polyolefin.
- E. Grounding Cover: Tinned-copper braid.
- F. Cable Cover: Tinned-copper braid.
- G. Terminate with waterproof, factory-assembled, nonheating leads with connectors at one end, and seal the opposite end watertight. Cable is to be capable of crossing over itself once without overheating.
- H. Maximum Operating Temperature (Power On): 150 deg F.
- I. Maximum Exposure Temperature (Power Off): 185 deg F.
- J. 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.

## 2.2 CONTROLS

- A. Pipe-Mounted Thermostats for Freeze Protection:
  - 1. Remote bulb temperature-control unit with adjustable range from 30 to 50 deg F.
  - 2. Snap action: open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
  - 3. Remote temperature-sensing bulbs on capillary, resistance temperature device, or thermistor for directly sensing ambient air or pipe-wall temperature.
  - 4. Corrosion-resistant, waterproof control enclosure.
- B. Control Panel:
  - 1. Microprocessor-based control with manual on, automatic, and standby/reset switch.
  - 2. Remote temperature sensors sense outside air temperature; programmable to energize the cable when temperature falls below 34 to 44 deg F.
  - 3. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
  - 4. Minimum 30 A contactor to energize cable or close other contactors.
  - 5. Ground-fault protection.
  - 6. Single-point control of heat tracing for freeze protection.
  - 7. Provide communication ports with contacts, RS485, or Ethernet interface for remote monitoring and alarm by central HVAC-control system. Coordinate type of connection ports with Section 230923 "Direct Digital Control (DDC) System for HVAC."

## **2.3 ACCESSORIES**

- A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.
- B. Warning Labels: See Section 230553 "Identification for HVAC Piping and Equipment."

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

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

### **3.2 INSTALLATION**

- A. Install electric heating cable at locations indicated and in accordance with NFPA 70.
- B. Install electric heating cable across expansion, construction, and control joints in accordance with manufacturer's written instructions; use cable-protection conduit and slack cable to allow movement without damage to cable.
- C. Install electric heating cables after piping has been tested and before insulation is installed.
- D. Install electric heating cables in accordance with IEEE 515.1.
- E. Install insulation over piping with electric cables in accordance with Section 230719 "HVAC Piping Insulation."
- F. Install warning tape on piping insulation where piping is equipped with electric heating cables.
- G. Set field-adjustable switches and circuit-breaker trip ranges.
- H. Install temperature-control units in an accessible location and in accordance with manufacturer's written instructions. Locate sensing bulbs to sense outside air temperature in a location where it will not be affected by direct sunlight or other heat sources.
- I. Install control panels and distribution panels where indicated and in accordance with manufacturer's written instructions.
- J. Install outside air and pipe temperature sensors.

### **3.3 ELECTRICAL CONNECTIONS**

- A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Connect temperature-control unit to interrupt power supply to electric heating cable when outside air is above set point.
- D. Connect remote electronic temperature sensors.

### **3.4 PROTECTION**

- A. Protect installed heating cables, including nonheating leads, from damage.
- B. Remove and replace damaged heat-tracing cables.

**END OF SECTION**

## **SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

A. Section Includes:

1. Elastomeric isolation pads.
2. Housed-restrained-spring isolators.
3. Pipe-riser resilient support.
4. Resilient pipe guides.
5. Spring hangers.
6. Restraints - rigid type.
7. Restraints - cable type.
8. Restraint accessories.
9. Vibration isolation equipment bases.
10. Seismically restrained isolation roof-curb rails.

#### **1.2 DEFINITIONS**

- A. Designated Seismic System: An architectural, mechanical, electrical, plumbing, or fire protection system and its components for which the component importance factor is greater than 1.0 when determined in accordance with ASCE/SEI 7.
- B. IBC: International Building Code.
- C. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

#### **1.3 DELEGATED DESIGN SERVICES**

- A. Delegated Design Professional: Engage qualified Missouri licensed professional structural engineer to design seismic and wind restraints.

#### **1.4 ACTION SUBMITTALS**

A. Product Data:

1. For each type of product.
  - a. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

2. Include load rating for each seismic and wind restraint device.
3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic and wind restraint component.
4. 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 ICC-ES product listing and authorities having jurisdiction.
5. Annotate to indicate application of each product submitted and compliance with requirements.
6. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

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 restraints for components with other systems and equipment in the vicinity, including other supports and other seismic restraints.

C. Delegated Design Submittals:

1. All delegated design and submittals for seismic and wind restraints must be signed and sealed by a qualified professional structural engineer responsible for their preparation. Structural engineer is to possess qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering, including design of seismic and wind restraints, equipment hangers and supports, and concrete attachments.
2. For each seismic-restraint device, including seismic-restrained mounting, pipe-riser resilient support, snubber, seismic restraint, seismic-restraint accessory, concrete anchor and insert, and restrained isolation roof-curb rail that is required by this Section or is indicated on Drawings, submit the following:
  - a. Seismic Restraint, Vibration Isolator, and Vibration Isolation Base Selection: Select and submit seismic restraints vibration isolators, and vibration isolation bases complying with performance requirements, design criteria, and analysis data.
  - b. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification by professional engineer that riser system was examined for excessive stress and that none exists.
  - c. Post-Installed Concrete Anchors and Concrete Inserts: Include calculations showing anticipated seismic loads. Include certification that device is approved by an NRTL for reinforcement use.
  - d. Seismic Design Calculations: Submit all input data and loading calculations.
3. For each wind-restraint device, including restraint - rigid, restraint - cable, restraint accessory, concrete anchor, and concrete insert that is required by this Section or is indicated on Drawings, submit the following:

- a. Wind Restraints: Select and submit wind restraints complying with performance requirements, design criteria, and analysis data.
  - b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated wind-resistant loads. Include certification that device is approved by an NRTL for reinforcement use.
  - c. Wind-Restraint Design Calculations: Submit all input data and loading calculations.
4. Seismic- and Wind-Restraint Detail Drawing:
  - a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
  - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to 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.
  - c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply also with requirements in other Sections for equipment mounted outdoors.
5. Product Listing, Preapproval, and Evaluation Documentation: By an evaluation service member of ICC-ES and authorities having jurisdiction, showing maximum ratings of restraint items and basis for approval (tests or calculations).
6. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.
7. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.

## **1.5 INFORMATIONAL SUBMITTALS**

- A. Field quality-control reports.

## **1.6 REGULATORY AGENCY APPROVALS**

- A. Delegated design submittals and Shop Drawings requiring approval by authorities having jurisdiction must be signed by qualified structural professional engineer responsible for their preparation. Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.



## **1.7 QUALIFICATIONS**

- A. Professional Structural Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering, including design of seismic and wind restraints, equipment hangers and supports, and concrete foundations.

## **1.8 CLOSEOUT SUBMITTALS**

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

## **1.9 QUALITY ASSURANCE**

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
- B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

## **PART 2 - PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS**

- A. Delegated Design: Engage qualified professional structural engineer to prepare seismic- and wind-restraint calculations in accordance with criteria specified in Section 018123 "Facility Seismic and Wind Criteria."
- B. Seismic- and Wind-Restraint-Device Load Ratings: Devices are to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices are 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: ICC-ES product listing and authorities having jurisdiction.
- C. Consequential Damage: Provide additional seismic and wind 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-restraint devices that are not constructed of ferrous metals are to 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 labeled as such.
- E. Component Supports:

1. Load ratings, features, and applications of reinforcement components are to be based on testing standards of qualified testing laboratory.

## **2.2 ELASTOMERIC ISOLATION PADS**

### **A. Elastomeric Isolation Pads:**

1. Source Limitations: Obtain elastomeric isolation pads from single manufacturer.
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.

## **2.3 HOUSED-RESTRAINED-SPRING ISOLATORS**

### **A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:**

1. Source Limitations: Obtain freestanding, open-spring isolators with vertical-limit stop restraints from single manufacturer.
2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.
  - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases limit floor load to 500 psig.
  - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

## **2.4 PIPE-RISER RESILIENT SUPPORT**

### **A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-Inch- Thick Neoprene:**

1. Source Limitations: Obtain resilient pipe-riser supports from single manufacturer.
2. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- thick neoprene.

3. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
4. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

## **2.5 RESILIENT PIPE GUIDES**

- A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-Inch- Thick Neoprene:

1. Source Limitations: Obtain resilient pipe guides from single manufacturer.
2. Description: Resilient pipe guide with telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch- thick neoprene.

## **2.6 SPRING HANGERS**

- A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

1. Source Limitations: Obtain spring hangers from single manufacturer.
2. Description: Combination coil-spring and elastomeric-insert hanger.
3. 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.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
9. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
10. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

## **2.7 RESTRAINTS - RIGID TYPE**

- A. Source Limitations: Obtain rigid-type restraints from single manufacturer.
- B. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, 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.

## **2.8 RESTRAINTS - CABLE TYPE**

- A. Source Limitations: Obtain cable-type restraints from single manufacturer.
- B. Seismic- and Wind-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 with cable fittings must comply with ASCE/SEI 19. All 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.

## **2.9 RESTRAINT ACCESSORIES**

- A. Source Limitations: Obtain restraint accessories from single manufacturer.
- 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 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.

## **2.10 VIBRATION ISOLATION EQUIPMENT BASES**

- A. Source Limitations: Obtain vibration isolation equipment bases from single manufacturer.
- B. Steel Rails: Factory-fabricated, welded, structural-steel rails.
  - 1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.
    - a. Include supports for suction and discharge elbows for pumps.
  - 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Rails to have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- C. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.
  1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
    - a. Include supports for suction and discharge elbows for pumps.
  2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases to have shape to accommodate supported equipment.
  3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- D. Concrete Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
  1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
    - a. Include supports for suction and discharge elbows for pumps.
  2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases to have shape to accommodate supported equipment.
  3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
  4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

## **2.11 SEISMICALLY RESTRAINED ISOLATION ROOF-CURB RAILS**

- A. Seismically Restrained Isolation Roof-Curb Rails:
  1. Source Limitations: Obtain restrained isolation roof-curb rails from single manufacturer.
  2. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.
  3. Upper Frame: To provide continuous support for equipment and to be captive to resiliently resist seismic and wind forces.

4. Lower Support Assembly: To be formed sheet metal section containing adjustable and removable steel springs that support the upper frame. Lower support assembly to have a means for attaching to building structure and a wood nailer for attaching roof materials, and to be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly. Mount adjustable, restrained-spring isolators on elastomeric vibration isolation pads and provide access ports, for level adjustment, with removable waterproof covers at all isolator locations. Locate isolators so they are accessible for adjustment at any time during the life of the installation without interfering with integrity of roof.
5. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.
6. 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**

#### **3.1 EXAMINATION**

- A. Examine areas and equipment to receive vibration isolation and seismic- and wind-restraint 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.

#### **3.2 APPLICATIONS**

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES and 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 due to seismic forces.
- C. Strength of Support and Assemblies: Where not specifically indicated otherwise, select sizes of components so strength is adequate to carry static, wind load, and seismic loads within specified loading limits.

#### **3.3 INSTALLATION OF VIBRATION CONTROLS AND SEISMIC RESTRAINTS FOR HVAC PIPING AND EQUIPMENT**

- A. Provide seismic- and wind-restraint devices and vibration-control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Devices Schedules, where indicated on Drawings, or where Specifications indicate they are to be installed on specific equipment and systems.

- B. Provide seismic-restraint and wind-restraint devices for systems and equipment where indicated in Equipment Schedules or Seismic-Restraint Devices Schedules, where indicated on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.
- C. 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."
- D. Installation of vibration isolators, wind restraints, must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- E. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- F. Equipment Restraints:
  - 1. Install snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
  - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
  - 3. Install seismic-restraint, and wind-restraint devices using methods approved by an evaluation service member of ICC-ES and authorities having jurisdiction that provides required submittals for component.
- G. Piping Restraints:
  - 1. Comply with requirements in MSS SP-127.
  - 2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
  - 3. Brace a change of direction longer than 12 feet.
- H. Ductwork Restraints:
  - 1. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with ASCE/SEI 7.
  - 2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
  - 3. Brace a change of direction longer than 12 feet.
  - 4. Select seismic-restraint devices with capacities adequate to carry static and seismic loads.
  - 5. Install cable restraints on ducts that are suspended with vibration isolators.
- I. Install seismic- and wind- restraint cables so they do not bend across edges of adjacent equipment or building structure.
- J. Install seismic- and wind- restraint devices using methods approved by an evaluation service member of ICC-ES and authorities having jurisdiction that provides required submittals for component.

- K. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- L. 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.
- M. 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.
- N. 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 Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors to be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
  - 4. Adhesive 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.

### **3.4 INSTALLATION OF AIR-SPRING ISOLATORS**

- A. Independent Isolator Installation:
  - 1. Install tank valve into each air isolator.
  - 2. Inflate each isolator to height and pressure required by manufacturer.
- B. Pressure-Regulated Isolator Installation:
  - 1. Coordinate the constant pressure-regulated air supply to air springs with requirements for piping and connections specified in Section 221513 "General-Service Compressed-Air Piping."
  - 2. Connect all pressure regulators to a single dry, filtered air supply.
  - 3. Inflate isolators to height and pressure required by manufacturer.



### **3.5 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION**

- A. Provide flexible connections in piping systems where they cross structural seismic 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.

### **3.6 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT BASES**

- A. 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."
- B. Coordinate dimensions of steel equipment rails and bases, concrete inertia bases, and restrained isolation roof-curb rails with requirements of isolated equipment specified in this and other Sections. Where dimensions of these bases are indicated on Drawings, dimensions may require adjustment to accommodate actual isolated equipment.

### **3.7 ADJUSTING**

- A. Adjust isolators after system is at operating weight.
- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

### **3.8 FIELD QUALITY CONTROL**

- A. Testing Agency: 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. Tests and Inspections:
  - 1. Perform tests and inspections with the assistance of a factory-authorized service representative.
  - 2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
  - 3. 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.
  - 4. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.

5. Test no fewer than four of each type and size of installed anchors and fasteners selected by Architect.
  6. Test to 90 percent of rated proof load of device.
  7. Measure isolator restraint clearance.
  8. Measure isolator deflection.
  9. Verify snubber minimum clearances.
  10. Test and adjust restrained-air-spring isolator controls and safeties.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Units will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

**END OF SECTION**

## **SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Equipment labels.
  - 2. Warning signs and labels.
  - 3. Warning tape.
  - 4. Duct labels.
  - 5. Valve tags.
  - 6. Warning tags.

#### **1.2 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment-Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve-numbering scheme.
- E. Valve Schedules: Provide for each piping system. Include in operation and maintenance manuals.

### **PART 2 - PRODUCTS**

#### **2.1 EQUIPMENT LABELS**

- A. Metal Labels for Equipment:
  - 1. Material and Thickness: Brass, 0.032-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
  - 2. Letter and Background Color: As indicated for specific application under Part 3.
  - 3. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

4. 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.
  5. Fasteners: Stainless steel rivets or self-tapping screws.
  6. 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.

## **2.2 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 and Background Color: As indicated for specific application under Part 3.
- C. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
- D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- E. 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.
- F. Fasteners: Stainless steel rivets or self-taping screws.
- G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- H. Arc-Flash Warning Signs: Provide arc-flash warning signs in locations and with content in accordance with requirements of OSHA and NFPA70E and other applicable codes and standards.
- I. Label Content: Include caution and warning information plus emergency notification instructions.

## **2.3 WARNING TAPE**

- A. Material: Vinyl.
- B. Minimum Thickness: 0.005 inch.
- C. Letter, Pattern, and Background Color: As indicated for specific application under Part 3.

- D. Waterproof Adhesive Backing: Suitable for indoor or outdoor use.
- E. Maximum Temperature: 160 deg F.
- F. Minimum Width: 4 inches.

## **2.4 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 and Background Color: As indicated for specific application under Part 3.
- C. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- E. 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.
- F. Fasteners: Stainless steel rivets or self-tapping screws.
- G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- H. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings. Also include the following:
  - 1. Duct size.
  - 2. Flow-Direction Arrows: Include flow-direction arrows on[ **main**] distribution ducts. Arrows may be either integral with label or may be applied separately.
  - 3. Lettering Size: Size letters in accordance with ASME A13.1 for piping.

## **2.5 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, 0.04-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
  - 2. Fasteners: Brass link chain or S-hook.
- B. Letter and Background Color: As indicated for specific application under Part 3.

- C. 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.

## **2.6 WARNING TAGS**

- A. Description: Preprinted accident-prevention tags of plasticized card stock.
  - 1. Size: 3 by 5-1/4 inches minimum.
  - 2. Fasteners: Brass grommet and wire.
  - 3. Nomenclature: Large-size primary caption, such as "DANGER," "CAUTION," or "DO NOT OPERATE."
  - 4. Letter and Background Color: As indicated for specific application under Part 3.

## **PART 3 - EXECUTION**

### **3.1 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.

### **3.2 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.
- D. Locate identifying devices so that they are readily visible from the point of normal approach.

### **3.3 INSTALLATION OF EQUIPMENT LABELS, WARNING SIGNS, AND LABELS**

- A. Permanently fasten labels on each item of mechanical equipment.
- B. Sign and Label Colors:
  - 1. White letters on an ANSI Z535.1 safety-blue background.
- C. Locate equipment labels where accessible and visible.

- D. Arc-Flash Warning Signs: Provide arc-flash warning signs on electrical disconnects and other equipment where arc-flash hazard exists, as indicated on Drawings, and in accordance with requirements of OSHA and NFPA 70E, and other applicable codes and standards.

### **3.4 INSTALLATION OF WARNING TAPE**

- A. Warning Tape Color and Pattern: Yellow background with black diagonal stripes marking pattern.
- B. Install warning tape on pipes and ducts, with cross-designated walkways providing less than 6 ft. of clearance.
- C. Locate tape so as to be readily visible from the point of normal approach.

### **3.5 INSTALLATION OF DUCT LABELS**

- A. Install plastic-laminated / self-adhesive 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 blue background.
    - c. For exhaust-, outside-, relief-, return-, and mixed-air ducts: White letters on blue background.
- B. Stenciled Duct-Label Option: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.
  - 1. For all air ducts: Black letters on white background.
- C. Locate label near each point where ducts enter into and exit from concealed spaces and at maximum intervals of [20 ft.] where exposed or are concealed by removable ceiling system.
- D. Stenciled Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:
  - 1. Black letters on White background.

### **3.6 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. Chilled Water: 1-1/2 inches, round.
- b. Condenser Water: 1-1/2 inches, round.
- c. Refrigerant 1-1/2 inches, round.
- d. Hot Water: 1-1/2 inches, round.
- e. Gas: 1-1/2 inches, round.

2. Valve-Tag Colors:

- a. For each piping system, use the same lettering and background coloring system on valve tags as used for the Pipe Label Schedule text and background.

### **3.7 INSTALLATION OF WARNING TAGS**

- A. Warning Tag Color: Black letters on an ANSI Z535.1 safety-yellow background.

### **END OF SECTION**



## **SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. The Work of this Section Includes:
  - 1. TAB of Air Systems:
    - a. Constant-volume air systems.
    - b. Variable-air-volume systems.
  - 2. TAB of Hydronic Piping Systems:
    - a. Variable-flow hydronic systems.
    - b. Primary-secondary hydronic systems.
  - 3. TAB of equipment.
  - 4. TAB of existing HVAC systems and equipment.
  - 5. TAB of boiler systems and equipment.
  - 6. Sound tests.
  - 7. Vibration tests.
  - 8. Pipe-leakage tests verification.
  - 9. HVAC-control system verification.

#### **1.2 DEFINITIONS**

- A. AABC: Associated Air Balance Council.
- B. FFT: Fast Fourier transform.
- C. INCE: Institute of Noise Control Engineering
- D. NC: Noise criteria.
- E. NEBB: National Environmental Balancing Bureau.
- F. RC: Room criteria.
- G. TAB: Testing, adjusting, and balancing.
- H. TABB: Testing, Adjusting, and Balancing Bureau.
- I. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

- J. TDH: Total dynamic head.
- K. UFAD: Underfloor air distribution.

### **1.3 INFORMATIONAL SUBMITTALS**

- A. Qualification Data: Within 60 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. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.
- C. System Readiness Checklists: Within 60 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article, to be used and filled out by systems installers verifying that systems are ready for TAB.
- D. Certified TAB Reports: Within 14 days of completion of testing and balancing work.
  - 1. Submit one copy of the final TAB report to the design professional of record's firm.
- E. Sample report forms.
- F. 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 and calibration interval.

### **1.4 QUALITY ASSURANCE**

- A. TAB Specialist Firm's Qualifications: Certified by NEBB or TABB.
  - 1. TAB Certified Professional: Employee of the TAB specialist firm and certified by NEBB or TABB.
  - 2. TAB Technician: Employee of the TAB specialist firm and certified by NEBB or TABB.
  - 3. TAB specialist firm is to be independent, third-party, and unaffiliated with Contractor.
- B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- C. ASHRAE 111 compliance for testing and balancing of HVAC systems.
- D. Code and Authorities Having Jurisdiction Compliance: Furnish TAB services that comply with governing codes and requirements of authorities having jurisdiction.

## **1.5 FIELD CONDITIONS**

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

## **PART 2 - PRODUCTS (Not Applicable)**

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in system designs that may preclude proper TAB of systems and equipment. Submit Contract Documents Examination Report summary of findings.
- 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. Note the locations of devices that are not accessible for TAB.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- E. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, clean and permanent filters are installed, and equipment with functioning controls is ready for operation.
- F. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning as indicated on Drawings or in the Specifications.
- G. Verify, with installation Contractor, that startup strainer screens have been replaced with permanent screens and that all strainers have been cleaned.
- H. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.
- I. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- J. Examine air vents to verify that air has been removed from all hydronic systems.

- K. Observe demonstration of operating safety interlocks and controls on HVAC equipment.
- L. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

### 3.2 PREPARATION

- A. Prepare system-readiness checklists 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 and are in normal operating positions.
    - j. Note location of balancing devices that are inaccessible.
    - k. UFAD-Specific Requirements:
      - 1) Verify that raised access panels are installed.
      - 2) Verify that air plenums are free of debris.
      - 3) Verify that air plenum dividers are installed.
      - 4) Follow procedures to measure Category 1 and 2 leakage in AABC's "National Standards to Total System Balance."
  - 2. Hydronics:
    - a. Verify leakage and pressure tests on water distribution systems have been completed in accordance with applicable code and authorities having jurisdiction.
    - b. Piping is complete with terminals installed.
    - c. Water treatment is complete.
    - d. Systems are flushed, filled, and air purged.
    - e. Verify that pressure at highest point in the system is a minimum of 5 psig.
    - f. Strainers are pulled and cleaned.
    - g. Control valves are functioning in accordance with the controls sequence of operation.
    - h. Shutoff and balance valves have been verified to be 100 percent open.
    - i. Pumps are started and proper rotation is verified.
    - j. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
    - k. Variable-frequency controllers' startup is complete, and safeties are verified.
    - l. Note location of balancing devices that are inaccessible.

### **3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING**

- A. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
  - 1. Installing Contractor to Perform the Following:
    - a. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
    - b. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
    - c. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
    - d. 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."
- B. 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.
- C. Take and report testing and balancing measurements in inch-pound (IP) units.
- D. 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.

### **3.4 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. Air curtains.
  - 5. Commercial kitchen hoods.
  - 6. Unit heaters.
  - 7. Condensers.
  - 8. Water chillers.
  - 9. Cooling towers.
  - 10. Boilers.
  - 11. Energy-recovery units.
  - 12. Dedicated outdoor-air units.
  - 13. Coils.
  - 14. Fan coil units.

### **3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS**

- A. Prepare test reports for both fans and outlets. Obtain approved submittals and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare single-line schematic diagram of systems or color-coded HVAC drawings for the purpose of identifying HVAC components, including each air terminal unit and each air diffuser, register, and grille.
- C. For variable-air-volume systems, develop a plan to simulate diversity and include in TAB plan.
- D. Determine suitable locations in main and branch ducts for accurate duct-airflow measurements.
- E. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
- F. Verify that motor controllers are equipped with properly sized thermal protection.

### **3.6 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.
  - 2. Measure fan static pressures as follows:
    - a. Measure static pressure directly at the fan outlet.
    - b. Measure static pressure directly at the fan inlet.
    - c. Measure static pressure differential across each component that makes up the air-handling system.
    - d. Apply artificial loading of filters to simulate a dirty filter pressure drop condition at the time static pressures are measured.
  - 3. Adjust fan speed higher or lower than indicated speed if required for balancing. 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.
  - 4. 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 volume dampers 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. Apply correction factors as applicable for each size and style of air device.
  - 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 range. Readjust to within design tolerance 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. Traverse the supply airflow in full airside economizer mode. Observe the mixed air plenum pressure as compared to normal operation: return air dampers open and minimum outside air varying to 100 percent outside air dampers fully open and return air dampers fully closed. Mixed air pressure is to remain constant plus/minus 20 percent or, otherwise, damper/fan adjustments will be required.
  - 5. Mark all final settings.
  - 6. Measure and record all operating data.
  - 7. Record final fan-performance data.

### **3.7 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. Set the air terminal units to maximum airflow. Record the following for each air terminal unit:
  - a. Design maximum airflow.
  - b. Tested and balanced maximum airflow.
  - c. BAS system maximum airflow.
  - d. BAS damper position.
  - e. Adjust the air-handling unit fan airflow until one air terminal unit damper position is 85 percent open.
  - f. Record the duct static pressure sensor and set the fan static pressure controller to the recorded static pressure sensor.
  - g. Record the fan operating Hz.
  - h. If the system has filters that will exceed 0.5 inch wg pressure differential when dirty, simulate the dirty filter pressure drop and repeat all the above recorded readings ("a" through "g"), noting dirty filter condition.
  - i. With N+1, isolate one fan and repeat all the above recorded readings ("a" through "g"), noting N+1 condition.
  - j. Each condition must have all air-handling- unit data recorded, including static pressure profiles at outdoor air, return air, relief air, total supply air, supply air fan suction and discharge, return air fan suction and discharge, and relief air fan suction and discharge.
6. Measure fan static pressures as follows:
  - a. Measure static pressure directly at the fan outlet.
  - b. Measure static pressure directly at the fan inlet.
  - 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.
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.

### **3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS**

- A. Prepare test reports for pumps, coils, and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Cross-check the summation of required coil and equipment flow rates with pump design flow rate.
- B. Prepare single-line schematic diagram of systems for the purpose of identifying HVAC components.
- C. Prepare schematic diagrams of systems' record Drawings piping layouts.
- D. 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.
- E. Measure and record upstream and downstream pressure of each piece of equipment.
- F. Measure and record upstream and downstream pressure of pressure-reducing valves.
- G. 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.

### **3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS**

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.
- B. Adjust the variable-flow hydronic system as follows:
  - 1. Verify that the pressure-differential sensor(s) is located as indicated.
  - 2. Determine whether there is diversity in the system.
- C. For systems with no flow diversity:
  - 1. Adjust pumps to deliver total design flow with variable frequency drive(s) set to 60 Hz.
    - a. Measure total water flow.
      - 1) Position valves for full flow through coils.
      - 2) Measure flow by main flow meter, if installed.
      - 3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
    - b. Measure pump TDH as follows:
      - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
      - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
      - 3) Convert pressure to head and correct for differences in gauge heights.
      - 4) 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.
    - c. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling. Before pump impellers are trimmed, verify future load requirements and close throttling valve, noting the position.
  - 2. Monitor motor performance during procedures, and do not operate motor in an overloaded condition. While operating pump(s) at maximum flow conditions, verify pump(s) are operating below nameplate and are non-overloading through full range of operation.
  - 3. Adjust flow-measuring devices installed in mains and branches to design water flows.
    - a. Measure flow in main and branch pipes.
    - b. Adjust main and branch balance valves for design flow by using manually balancing valve.
    - c. Re-measure each main and branch after all have been adjusted.

4. Adjust flow-measuring devices installed at terminals for each space to design water flows.
    - a. Measure flow at terminals.
    - b. Adjust each terminal to design flow.
    - c. Re-measure each terminal after it is adjusted.
    - d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
    - e. Perform temperature tests after flows have been balanced.
  5. For systems with pressure-independent valves at terminals:
    - a. Measure differential pressure and verify that it is within manufacturer's specified range.
    - b. Perform temperature tests after flows have been verified.
  6. For systems without pressure-independent valves or flow-measuring devices at terminals:
    - a. Measure and balance coils by either coil pressure drop or temperature method.
    - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
  7. Prior to verifying final system conditions, determine the system pressure-differential set point(s).
  8. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, verify the pressure at the controller sensor and set the controller to the measured pressure at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions. Reverify the pressure at the controller.
  9. Mark final settings and verify that all memory stops have been set.
  10. Verify final system conditions as follows:
    - a. Re-measure and confirm that total flow is within design.
    - b. Re-measure final pumps' operating data, TDH, volts, amps, speed, static pressure profile, and variable-frequency drive Hz.
    - c. Mark final settings.
- D. For systems with flow diversity:
1. Determine diversity factor.
  2. Simulate system diversity by closing required number of control valves located closest to the pump(s).
  3. Adjust pumps to deliver total design flow.
    - a. Measure total water flow.
      - 1) Position valves for full flow through coils.
      - 2) Measure flow by main flow meter, if installed.

- 3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
  - b. Measure pump TDH as follows:
    - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
    - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
    - 3) Convert pressure to head and correct for differences in gauge heights.
    - 4) 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.
  - c. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling. Before pump impellers are trimmed, verify future load requirements and close throttling valve, noting the position.
4. Monitor motor performance during procedures, and do not operate motor in an overloaded condition. While operating pump(s) at maximum flow conditions, verify pump(s) are operating below nameplate and are non-overloading through full range of operation.
  5. Adjust flow-measuring devices installed in mains and branches to design water flows.
    - a. Measure flow in main and branch pipes.
    - b. Adjust main and branch balance valves for design flow.
    - c. Re-measure each main and branch after all have been adjusted.
  6. Adjust flow-measuring devices installed at terminals for each space to design water flows.
    - a. Measure flow at terminals.
    - b. Adjust each terminal to design flow.
    - c. Re-measure each terminal after it is adjusted.
    - d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
    - e. Perform temperature tests after flows have been balanced.
  7. For systems with pressure-independent valves at terminals:
    - a. Measure differential pressure, and verify that it is within manufacturer's specified range.
    - b. Perform temperature tests after flows have been verified.
  8. For systems without pressure-independent valves or flow-measuring devices at terminals:
    - a. Measure and balance coils by either coil pressure drop or temperature method.

- b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- 9. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
- 10. Prior to verifying final system conditions, determine system pressure-differential set point(s).
- 11. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
- 12. Mark final settings and verify that memory stops have been set.
- 13. Verify final system conditions as follows:
  - a. Re-measure and confirm that total water flow is within design.
  - b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
  - c. Mark final settings.

### **3.10 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 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. Before pump impellers are trimmed, verify future load requirements and close throttling valve, noting the position.

- 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. Before pump impellers are trimmed, verify future load requirements and close throttling valve, noting the position.
  3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition. While operating pump(s) at maximum flow conditions, verify pump(s) are operating below nameplate and are non-overloading through full range of operation.
- 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 balanced.
- 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.

### **3.11 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. Service factor and frame size.

- B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation. Verify and report Hz at maximum and minimum flows.

### **3.12 PROCEDURES FOR WATER CHILLERS**

- A. Air-Cooled Chillers: Balance water flow through each evaporator to within specified tolerances of indicated flow, with all pumps operating. With only one chiller operating in a multiple-chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
  2. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer or via chiller control panel readout.
  3. Power factor if factory-installed instrumentation is furnished for measuring kilowatts or via chiller control panel readout.
  4. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts or via chiller control panel readout.
  5. Capacity: Calculate in tons of cooling via chiller control panel readout.
  6. Verify condenser-fan rotation and record fan and motor data, including number of fans and entering- and leaving-air temperatures.
- B. Water-Cooled Chillers: Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow, with all pumps operating. With only one chiller operating in a multiple-chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
  2. Condenser-water entering and leaving temperatures, pressure drop, and water flow.
  3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer or via chiller control panel readout.
  4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts or via chiller control panel readout.
  5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts or via chiller control panel readout.
  6. Capacity: Calculate in tons of cooling via chiller control panel readout.

### **3.13 PROCEDURES FOR COOLING TOWERS**

- A. Performance Testing: Comply with CTI ATC-105 test procedure.
- B. Closed-Circuit Cooling Towers: Balance total condenser-water flows to towers and cells. Measure and record the following data:
  - 1. Unit number.
  - 2. Manufacturer.
  - 3. Model number.
  - 4. Serial number.
  - 5. Number of cells.
  - 6. Capacity in cooling tons.
  - 7. Design and actual fan rpm.
  - 8. Flow rate in gpm.
  - 9. Condenser-water flow to each cell of the cooling tower.
  - 10. Pressure drop through each cell.
  - 11. Entering- and leaving-water temperatures.
  - 12. Wet- and dry-bulb temperatures of entering air.
  - 13. Wet- and dry-bulb temperatures of leaving air.
  - 14. Barometric pressure, wind speed, and wind direction.
  - 15. Condenser-water flow rate recirculating through the cooling tower.
  - 16. Cooling-tower spray pump discharge pressure.
  - 17. Condenser-water flow through bypass.
  - 18. Makeup-water flow rate.
  - 19. Makeup-water temperature.
  - 20. Fan, motor, and motor controller operating data.
  - 21. Cooling-tower spray pump and motor operating data.
  - 22. Heater operating data.
- C. Open-Circuit Cooling Towers: Balance total condenser-water flows to towers and cells. Measure and record the following data:
  - 1. Condenser-water flow to each cell of the cooling tower.
  - 2. Pressure at each inlet connection.
  - 3. Entering- and leaving-water temperatures.
  - 4. Range (cooling tower inlet water temperature minus cooling tower outlet water temperature).
  - 5. Makeup-water flow rate.
  - 6. Makeup-water temperature.
  - 7. Wet- and dry-bulb temperatures of entering air.
  - 8. Wet- and dry-bulb temperatures of leaving air.
  - 9. Approach (ambient wet bulb minus leaving water temperature).
  - 10. Barometric pressure, wind speed, and wind direction.
  - 11. Fan, motor, and motor controller operating data.
  - 12. Heater operating data.



### **3.14 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. Fan, motor, and motor controller operating data.

**B. Gas-Fired Boilers:**

1. Test and document proper operation of emergency gas shut-down switch.

### **3.15 PROCEDURES FOR KITCHEN EXHAUST HOODS**

**A. Room Pressure:** Measure and record room pressure with respect to atmosphere and adjacent space with hoods in room initially not operating and then with hoods operating.

**B. Makeup Air:** Systems supplying source of makeup air to hoods are to be in operation during testing and balancing of exhaust hoods.

1. Measure and record temperature of makeup air entering hood. If hood makeup air is from multiple sources having different temperatures, measure and record the airflow and temperatures of each source and calculate the weighted average temperature.
2. Use simulated smoke to observe supply air-distribution air patterns in vicinity of hoods. Consult with hood manufacturer and report conditions that have a detrimental effect on intended capture, containment, and other attributes effecting proper operation.

**C. Canopy Hoods:** Measure and record the following:

1. Airflow by duct traverse where duct distribution will allow accurate measurement, and calculate hood average face velocity.
2. Measure velocity across hood face and calculate hood airflow.
  - a. Clearly indicate the direction of flow at each point of measurement.
  - b. Measure velocity across opening on not less than 12-inch centers. Record velocity at each measurement, and calculate average velocity.
3. Capture and Containment: Check each hood for proper capture and containment using a smoke-emitting device. Observe and report performance. Make adjustments to achieve optimum results.

**D. Kitchen Grease Hoods:**

1. Testing Procedure:

- a. Type 1: Measure and record pressure drop and face velocity of hood filters and slots in accordance with hood manufacturer's written instructions. Consult hood manufacturer to determine hood airflow using recorded information.
    - b. Type 2: Measure and record airflow by duct traverse.
    - c. Capture and Containment: Check each hood for proper capture and containment using a smoke-emitting device. Observe and report performance. Make adjustments to achieve optimum results.
  2. Testing: Testing procedure is to be in accordance with AABC's "National Standards for Total System Balance."
- E. Authorities Having Jurisdiction Tests: Conduct additional tests required by authorities having jurisdiction.

### **3.16 SOUND TESTS**

- A. After systems are balanced and Substantial Completion, with all systems operating at normal conditions and with all spaces completed and finished for occupancy, measure and record sound levels at five locations as designated by Architect. All building mechanical, electrical, and plumbing equipment, which may affect sound readings, must be operational.
- B. Sound-Level Testing Meter Instrumentation - Minimum Requirements:
1. Portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
  2. Capable of showing fluctuations at minimum and maximum levels and measuring the equivalent continuous sound pressure level ( $L_{eq}$ ).
  3. Capable of using one-third octave band filters to measure frequencies from 31.5 Hz to 8000 Hz.
  4. Accuracy of plus/minus two decibels.
  5. Current NIST-traceable annual calibration. Calibrate instruments prior to taking measurements and after taking measurements each day of use.
- C. Test Procedures - Indoors:
1. Measure and record sound levels at the following rooms:
    - a. Dormitory mechanical room with chillers and boilers.
    - b. Dormitory rooms located above or directly adjacent to the chiller / boiler mechanical room.
    - c. Dormitory area well directly outside mechanical room.
  2. For each room/location tested, select a measurement location that has the greatest anticipated sound level. If testing multiple locations for each room type, select at least one location that is near and at least one location that is remote from the predominant sound source.
  3. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.

4. Equipment is to be operating at design values.
5. Sound-testing firm is to have access to controls hardware, software, and onsite technical support at no cost to the sound-testing firm. The installing contractors are to provide a controlled, steady-state environment (flow, pressure, control, and temperature) during the duration of sound testing.
6. Use a microphone suitable for the type of noise levels measured that is compatible with meter.
7. At each measurement location, record a set of background sound pressure levels, with fast time constant and minimum time duration of 60 seconds, in the eight unweighted octave bands 63 Hz to 8000 Hz (NC) with the equipment off.
8. At each measurement location, record a set of sound pressure levels, with fast time constant and minimum time duration of 60 seconds, in the eight unweighted octave bands 63 Hz to 8000 Hz (NC) with the equipment operating.
9. Take readings no closer than 36 inches from a wall or from the operating equipment and approximately 48 inches from the floor, with the meter held or mounted on a tripod.

D. Test Procedures - Outdoors:

1. Make outdoor measurements at property lines.
2. Make measurements when background noise sources are at a minimum or when they do not affect equipment sound levels such as when the background noise levels are at least 10 dB less than the equipment noise levels.
3. Use microphone suitable for the type of noise levels measured that is compatible with the meter and as recommended by the sound-level meter manufacturer.
4. Provide a windshield for outside measurements whenever wind speed is greater than 5 mph.

E. Reporting:

1. The final report is to contain the following information at a minimum:
  - a. Report Title Page: Page indicating Project name, names of Project Architect, engineer, HVAC Contractor, and sound measurement firm with names, addresses, and telephone numbers.
  - b. Report Certification Page: Page indicating Project name, sound measurement firm name, name of individual performing measurements, and all required sound technician certifications.
  - c. Table of Contents: Identify report sections and total number of pages in each section.
  - d. Report Summary/Remarks: Narrative description of system setup conditions, results, and deficiencies.
  - e. Instrument Calibration Section: List of instruments to be used to verify the reported data, containing the name/type of each instrument, manufacturer, model number, serial number, calibration date and dates of use, and NIST-traceable calibration certificates.

- f. Sound Measurement Data Sheets: Record sound measurements on sound measurement report forms, indicating the decibel levels measured for both "background" and "building system operating" readings. Record each tested location on a separate NC or RC chart. Record the following information on the forms:
  - 1) Date and time of test.
  - 2) Equipment Operational Parameters: Speed and frequency at time of measurements.
  - 3) Indoor Measurements: Space location within the building, including floor level and room space number.
  - 4) Outdoor Measurements: Location identifier such as location relative to equipment, building, or property line.
  - 5) Indicate where measurements meet or exceed design criteria.

### **3.17 VIBRATION TESTS**

- A. After systems are balanced and Substantially Completion, measure and record vibration levels on equipment having motor horsepower equal to or greater than 3 for pumps and fans, 5 for chillers and compressors.
- B. Instrumentation:
  - 1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
  - 2. Meter is to automatically identify engineering units, frequency resolution, filter bandwidth, amplitude, and frequency scale values.
  - 3. Meter is to be able to measure machine vibration displacement in mils of deflection; velocity in inches per second (meters/sec); and acceleration in G's (or g-force), inches per second squared (G's, meters per second squared).
  - 4. Calibration of instrument and transducer must be NIST traceable and must be current during the time period measurements are being made. Vibration instruments and transducers must have NIST-traceable calibration every 12 months. Verify calibration date is current for vibration meter before taking readings.
- C. Pretest Procedures:
  - 1. Before any vibration measurements are made, confirm that the following items have been completed and any deficiencies found are reported to the appropriate parties for remedy:
    - a. Verify that all vibration isolators are installed in accordance with respective manufacturer's written instructions.
    - b. Verify that piping, duct, and conduit penetrations through mechanical equipment room envelope are sealed, and that there is no rigid contact with building structure.
    - c. Inspect steel isolation bases for cracked welds and bending/twisting of steel members.
    - d. Inspect concrete isolation bases for cracked concrete. Check isolator retainer brackets to be sure they are not loose. Concrete base must be flat and true level.

- e. Examine elastomeric isolators for cracks in the rubber and for loose bonds between the rubber and the steel plates and other steel components. Verify clearance is provided between bolts and the side of bolt holes to prevent short circuiting.
- f. Examine steel spring isolators for loose or missing bolts, nuts, and lock washers. Verify springs are not overloaded or underloaded, completely collapsed, or cocked. Verify rubber or glass-fiber pad between bottom steel spring plate and the concrete/supporting structure is in place.
- g. Inspect isolators that have seismic restraint devices to make sure that all shims have been removed and supportive nuts have been properly adjusted to allow for free floating of the isolated system.
- h. Verify that seismic restraints are not preventing proper functioning of vibration isolation function.
- i. Verify space under isolated bases are clean and free of debris that could cause short-circuiting.
- j. Verify that shipping bolts associated with spring isolators have been removed so that they do not short-circuit the system.
- k. Verify flexible piping, hoses, and expansion joint types, lengths, and locations are as specified.
- l. Verify that electrical and control connections do not restrain movement of the vibration-isolated equipment.
- m. Verify flexible connections between fans and ductwork "bellow" as designed when fans are operating.
- n. Verify that hanger isolator rods are free of misalignment and not in rigid contact with the hanger housing.

D. Test Procedures:

- 1. Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not adversely influence measurements of equipment being tested.
  - 2. Observe if there is equipment in the building that might interfere with testing. Note the equipment to the Construction Manager and request resolution before testing begins.
  - 3. Take measurements when exterior vibration sources, such as trains, roadway traffic, adjacent construction activities, and the like, are at a minimum level.
  - 4. Attach and secure vibration transducer in accordance with the most current edition of NEBB's "Procedural Standards for Measurement of Sound and Vibration.
  - 5. Measure and record vibration levels in at least 1.25 Hz increments over a minimum frequency range of 5 to 1000 Hz.
  - 6. Measure and record acceleration and/or velocity and/or displacement readings on equipment; bearing and equipment base in the vertical, horizontal, and axial planes; or as per-contract specifications, where measurements can be performed safely and where measurement locations are accessible.
- a. Pumps:
- 1) Pump Bearing: Drive end and opposite end.
  - 2) Motor Bearing: Drive end and opposite end.
  - 3) Equipment Base: Top and side, within 6 inches of one isolator.

- 4) Building: Floor adjacent to pump/motor, within 6 inches of one isolator; vertical axis only.
  - b. Fans and HVAC Equipment with Fans:
    - 1) Fan Bearing: Drive end and opposite end.
    - 2) Motor Bearing: Drive end and opposite end.
    - 3) Equipment Base: Top and side, within 6 inches of one isolator; vertical axis only.
  - c. Chillers and HVAC Equipment with Compressors:
    - 1) Compressor Bearing: Drive end and opposite end.
    - 2) Motor Bearing: Drive end and opposite end.
    - 3) Equipment Base: Top and side, within 6 inches of one isolator.
    - 4) Building: Floor adjacent to pump/motor, within 6 inches of one isolator; vertical axis only.
7. FFT Analyzer Settings:
  - a. Windowing: Hanning.
  - b. Averages: At least two.
  - c. Frequency Range: 5 to 1,000 Hz (300 to 60,000 rpm).
  - d. Frequency Resolution: At least 1.25 Hz (75 rpm).
  - e. Line of Resolution: At least 800.
  - f. Detection: Peak, peak-to-peak, or RMS.
  - g. Averaging: Exponential.
- E. Reporting:
  1. Vibration Measurement Report Forms:
    - a. For each measurement location, record vibration measurements on appropriate test forms, showing the following information:
      - 1) Date of test.
      - 2) Equipment designation, location, motor horsepower, and equipment operational parameters (speed/frequency) at time of test.
      - 3) Measured acceleration, in units of g's (g-force).
      - 4) Measured displacement, in units of inches, mils.
      - 5) Vibration level plot of vibration amplitude versus frequency for each measurement location.
      - 6) Verify vibration amplitude level plot versus frequency for each measurement location.
  2. Verify actual vibration against vibration limits. Follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from ASHRAE Handbook - "HVAC Applications," Ch. "Noise and Vibration Control". Acceptable levels of vibration are normally "smooth" to "good."

3. Include General Machinery Vibration Severity Chart with all conditions plotted.
4. Test each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.
5. Include horizontal-vertical-axial measurements for tests.

### **3.18 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.

### **3.19 HVAC CONTROLS VERIFICATION**

- A. In conjunction with system balancing, perform the following:
  1. Work to ensure the system is operating within the design limitations and gain a mutual understanding of intended controls performance.
  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.

### **3.20 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 10 percent or minus 5 percent. If design value is less than 100 cfm, flow rate is within 10 cfm.
  2. Air Outlets and Inlets: Plus 10 percent or minus 5 percent. If design value is less than 100 cfm, flow rate is within 10 cfm.
  3. Heating-Water Flow Rate: Plus or minus 5 percent. If design value is less than 10 gpm, flow rate is within 10 percent.
  4. Chilled-Water Flow Rate: Plus or minus 5 percent. If design value is less than 10 gpm, flow rate is within 10 percent.
  5. Condenser-Water Flow Rate: Plus or minus 5 percent.

- B. Maintaining pressure relationships as designed is to have priority over the tolerances specified above. If the above tolerances change the relative positive or negative airflow from/into the space, tolerances are to be adjusted so as to keep the relative positive cfm or negative cfm from/into the space a constant cfm differential.

### **3.21 PROGRESS REPORTING**

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance-measuring and -balancing devices.
- B. Status Reports: Prepare monthly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

### **3.22 FINAL TESTING AND BALANCING 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 firm and technician.
  - 3. Project name.
  - 4. Project location.
  - 5. Project Architect's name, firm, and address.
  - 6. Project engineer's name, firm, and address.
  - 7. Project Contractor's name, firm, 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 fan 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. Variable-frequency controller 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 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. Recorded inlet steam pressure in psig, as read from installed gauge.

G. Gas-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. Motor horsepower and speed.
- h. Motor volts, phase, and hertz.
- i. Motor full-load amperage and service factor.
- j. Sheave make, size in inches, and bore.
- k. 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. Motor voltage at each connection.
- i. Motor amperage for each phase.

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 and interval.

**3.23 VERIFICATION OF TAB REPORT**

- A. The TAB specialist firm's test and balance technician is to conduct the final verification in the presence of Owner.
- B. Engineer to randomly select measurements, documented in the final report, to be rechecked. Rechecking is to be limited to the lesser of either 10 percent of the total measurements recorded.
- C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements are to be noted as "FAILED."
- D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the TAB are to be considered incomplete and are to be rejected.
- E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:
  1. TAB specialists are to recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes are to be tracked to show changes made to previous report.
  2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.
- F. Prepare test and inspection reports.

**3.24 ADDITIONAL TESTS**

- A. Within four full seasons of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

**END OF SECTION**

# Johnson Controls: Metasys System User Interface Graphic Specification







# Metasys System Division 23 Graphics Specification

## 1. Quality Control for Metasys Graphics and User Interface

- i. Missouri State Highway Patrol (MSHP) utilizes central server that will house all Metasys User Interface graphics across the State. All MSHP locations must push back graphics to main server located in Jefferson City to ensure consistency and accessibility.
- ii. MSHP requires uniform graphics format across all troops and building locations. Johnson Controls Inc. (JCI) has a dedicated graphics team responsible for implementing standardized graphics, equipment relationships, and interface across all sites.
- iii. MSHP mandates standard naming conventions for all hardware, equipment, and points. BAS contractor to include at least one (1) day to review naming conventions with MSHP's facilities division and JCI's graphics team to ensure proper implementation.
- iv. To ensure seamless collaboration across all MSHP sites, contact Johnson Controls Representative Jack Conroy at
  - a) Phone: 314-624-7181
  - b) Email: [jack.conroy@jci.com](mailto:jack.conroy@jci.com)

## 2. Dedicated Web Based User Interface

- a. Where indicated on plans the BMS Contractor shall provide and install a personal computer for command entry, information management, network alarm management, and database management functions. Real-time control functions, including scheduling, history collection and alarming, shall be resident in the BMS Network Automation Engines and Data Server(s) to facilitate greater fault tolerance and reliability.
- b. Dedicated User Interface Architecture – The architecture of the computer shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BMS Contractor and by other third party applications suppliers, including but not limited to Microsoft Office Applications. Specifically, it must be implemented to conform to the following interface standards.

## 3. Mobile, Web Based, User Interface (MUI)

- a. General
  - i. The mobile, web-based, user interface shall be HTML5-compliant and provide access to the system from smartphones, tablets, portable and desktop computers. User Interfaces that require software installation on the client device (e.g. Java, Microsoft Silverlight®, Adobe® Flash®), or software downloads from an online app store shall not be acceptable for these purposes.
  - ii. The mobile user interface shall provide system operators with a simple location-based navigation approach to finding information, including the ability to search for any location by name and to bookmark a location in a standard browser.
  - iii. The mobile user interface shall organize and display information using customer specific locations and spaces. At a minimum, the user interface shall provide:
    - Organization of all space, equipment and point information in a familiar way (using standard equipment names and location descriptions), reducing the need for extensive training prior to use.
    - A navigation mechanism or tree for users to select the specific location or space for accessing information – only spaces and locations in the navigation tree or equipment serving that space, nothing more.
    - The ability to search for and/or bookmark any location, space, or equipment by name for quick access to critical or troublesome areas.
    - Application of the same navigation mechanisms across any client device (e.g. Smart phone, tablet, personal computer) for consistency and ease of use.
  - iv. The same user interface elements shall be accessible from any type of personal computer or mobile device running any type of operating system supported (e.g. iOS, Android, Windows®).

It shall automatically adapt and optimize the display for the screen size and touch screen navigation.

- v. The user interface shall provide support for up to 50 concurrent users from individuals with defined access to the system.

b. Navigation Trees

- i. A dedicated location based navigation tree shall be provided as part of the user interface in order to navigate to specific places within the facility on a hierarchical basis (typ. Facility, Building, Wing, Floor, Room).
- ii. The location-based tree shall use place names familiar to the operator without training or familiarization regarding special codes and conventions utilized in the generation of the BMS.
- iii. Clicking or tapping on a location name in the tree shall display the home page associated with the space and simultaneously expand the tree to display the next level of spaces below the one selected.
- iv. It shall be possible for qualified users to view a navigation tree of devices connected to the BMS network in order to enable troubleshooting of equipment and communications. Clicking or tapping on the Network Icon at the top of the Navigation Tree will access this alternate view. Users without the necessary access rights shall not see the Network Icon.
- v. A click or tap on a device in the network tree shall display a dashboard for that device including information regarding related equipment and access to a separate focus view of commandable points associated with the piece of hardware. A click or tap on such a point shall display a control dialogue box allowing the user to modify or command that point as indicated. The dialog box shall contain an annotation box for describing why the action was taken or special circumstances that apply.
- vi. Specific hardware and software types in the Network tree shall also include access to one or more the following views in their dashboard depending on hardware type or network element (e.g. MS/TP trunk):
  - Summary View
  - Diagnostic View
  - Network View
  - Trend View
- vii. It shall be possible to hide the Network Tree and return to the Spaces Tree at any time by clicking on the Spaces Icon above the tree.
- viii. It shall be possible to restrict user access to any space in the Spaces Tree and thereby prevent manipulation of equipment associated with the space.

c. Dashboard Displays

- i. The user interface shall provide the ability to view equipment visualizations, floor plans, and/or other graphics on mobile or desktop client devices in a browser environment, without the need for additional plugins or software. Graphics shall be accessible via a space (for floorplans, campus maps, etc.) or equipment dashboard.
- ii. Standard dashboards shall be configured for each defined space including one of the following predefined or custom elements:
  - Equipment Serving Space
  - Potential Problem Areas
  - Equipment Summary
  - Graphic Display (if specified)
  - Schedule
- iii. Standard dashboards shall be configured for each system or device (typ. mechanical or electrical equipment) including the following predefined or custom elements:
  - Trend
  - Equipment Activity Summary

- Equipment Relationships Summary
  - Equipment Data
  - Graphic Display (if specified)
  - Schedule
- iv. Users with appropriate permissions shall have access to a Dashboards Manager that can change the display order of Summaries and Data elements, add or remove elements and apply custom dashboards layouts to equipment and space by type.
  - v. Dashboard Manager shall apply dashboards to spaces or equipment based on the viewing platform (Desktop/Tablet or Phone) in order to tailor the user experience to the needs of the specific user base.
  - vi. Default dashboard displays by space and equipment type shall be created per the guidelines in this specification or by mutual agreement with the owner's representative.
- d. Alarm Management
- i. The user interface shall provide a single display of all potential issues in a facility including items currently in alarm, warning, override, out-of-service and offline.
  - ii. The user interface shall provide notification of new alarms, visually and audibly.
  - iii. The user interface shall provide the ability to view a summary of alarms, including a chart of the number of alarms in each of the defined alarm priority ranges. The priority ranges should be filterable.
  - iv. The user interface shall provide the capability to view multiple occurrences of the same alarm, ultimately providing the ability to acknowledge or discard all occurrences of the alarm in a single action.
  - v. The user interface shall provide the capability to view, and filter on, all alarms present in a well-defined mechanical system using the equipment serving equipment relationships.
  - vi. The user interface shall provide the capability to acknowledge and discard all occurrences of at least 1000 alarms in one operation.
  - vii. The user interface shall provide the user with the understanding of what physical space is being affected when an alarm occurs. The user interface shall provide the ability to filter alarms by physical space affected when the alarm occurred.
  - viii. The user interface shall provide the capability to monitor alarms 24/7 without requiring an active login to the system, accessible via segregated web page. The user interface shall provide the capability to enable or disable the 24/7 alarm monitor mode if desired.
  - ix. The user interface shall provide the capability to annotate alarms using a pre-defined selection list or by providing custom text.
  - x. The user interface shall provide the capability to filter down alarm list and bookmark the filtered list, allowing automatic filtering to be applied when the bookmark is accessed.
  - xi. It shall be possible to export a .csv or .pdf copy of the currently displayed alarm list.
  - xii. If an alarm is not acknowledged or discarded by recipients within a user-selected time, the alarm shall be sent to an additional set of recipients.
- e. Equipment Activity Summary
- i. The user interface shall provide a filterable, single display, of all activity related to a specific piece of equipment including user changes, discarded user changes, pending alarms, discarded alarms, and acknowledged alarms for at least one year of historical data.
  - ii. Items shall be listed in timed order with the latest activity at the top of the list.
  - iii. Filters shall allow only specific activities for specific data points occurring within a specific time and date window to be displayed.
  - iv. It shall be possible to export a .csv copy of the currently displayed summary by clicking or tapping on the export icon.

- v. It shall be possible to create a custom trend graph containing the data shown in the currently displayed summary by tapping or clicking on the trend icon in the header bar and selecting the specific points to trend in the resulting selection panel.
- vi. Clicking on the information icon in front of any displayed activity listed in the summary shall expand the display to include the name of the user, server time, value prior to the activity, the ability to annotate the activity and a user selectable icon for displaying a trend graph of the point.
- f. Equipment Relationships Summary
  - i. The user interface shall provide a summary of all equipment and spaces related to the operation of the system or device currently selected for viewing.
  - ii. The user interface shall include the capability to navigate to the home page of any related piece of equipment or space with a single click or tap on the desired element.
- g. Equipment Data Summary
  - i. The user interface shall provide a summary of all data pertaining to a particular piece of mechanical or electrical equipment in a tabular format.
  - ii. Clicking or tapping on any value in the summary shall display a related command panel allowing the user to command, override, or change service condition of the point selected and to annotate such actions for future reference.
  - iii. It shall be possible to export a .pdf copy of the report with a single click on the associated export icon.
- h. Equipment Serving Space Summary
  - i. The user interface shall provide a summary of all mechanical and electrical equipment as defined in the points list that serves a selected space from the navigation tree.
  - ii. The summary shall be capable of including a subset of the viewable points for each system representing the key elements of interest to operators without subjecting them to long lists of points irrelevant to basic operation.
  - iii. Clicking or tapping on any item in the summary shall navigate to the item's assigned home page in the user interface.
  - iv. It shall be possible to view a custom trend of information contained in the summary with a single click of the trend icon residing in the title header.
  - v. It shall be possible to display specific systems and points by filtering equipment types desired.
  - vi. Because the data is intended to be a snapshot of the current conditions in the space it shall not dynamically update but a click or tap on the update icon at any time performs that function.
- i. Potential Problem Areas
  - i. The user interface shall provide a summary of all points in the system related to the space that are not operating correctly (e.g. alarm, off normal or not communicating correctly) in order to provide the operator with a quick update on current conditions.
  - ii. The information shall include:
    - Point status (via color)
    - Point name
    - Value of the point when the summary was taken
    - Equipment that contains the offending point
    - Space that is served by that equipment
  - iii. Data points in the summary may be filtered by one or more types of off-normal condition (e.g. above setpoint, offline and overridden).
  - iv. The summary may be exported in .csv format for inclusion in spreadsheets or other documents.
- j. Equipment Summary

- i. The user interface shall provide a summary that allows the user to compare all similar equipment that serves the space as well as downstream (child) spaces in order to evaluate conditions quickly and determine patterns for troubleshooting purposes.
  - ii. Each unique equipment type shall be selectable and display a representative set of values along with the space(s) being served by the device. Equipment types can be selected from a dropdown menu in the summary.
  - iii. Clicking or tapping on a selected device in the summary shall navigate to the home page for that piece of equipment while clicking or tapping a data point shall display the command panel for that point.
  - iv. It shall be possible to export a .pdf copy of the currently displayed summary by clicking or tapping on the export icon.
  - v. It shall be possible to create a custom trend graph containing the data shown in the currently displayed summary by clicking on the trend icon in the header bar and selecting the specific points to trend in the resulting selection panel.
- k. User Defined Summaries
- i. Provide the capability to view, command, and modify large quantities of similar data in summaries without the use of a secondary application (e.g. a spreadsheet). These summaries shall be generated automatically or user defined. User defined summaries shall allow up to seven user defined columns describing attributes to be displayed including custom column labels with up to 100 rows per summary.
- l. Trend
- i. The user interface shall provide the capability to view historical trend data from multiple pieces of equipment in both bar and line formats.
  - ii. The user shall have the ability to navigate to a selection list of frequently viewed trends.
  - iii. Trend graphs shall have the ability to be smartly auto-generated based on equipment and space relationships.
  - iv. The user shall have the ability to view up to 3 graphs in a single screen and select which data points to plot on each to help with readability.
  - v. Each graph shall include a dedicated selection icon to export a copy of the graphic and data in .pdf format or the data only as a .csv file.
- m. Operator Access
- i. The user interface shall provide the ability to segment access to building data based on the space(s) or location(s) the user is physically located in and/or manages. The user interface shall provide the capability to assign "inherited" space permissions and the ability to assign user's space based access in bulk.
  - ii. The user interface shall provide the ability to segment access to building data based on the space(s) or location(s) the user is physically located in and/or manages. The user interface shall provide the capability to assign "inherited" space permissions and the ability to assign user's space based access in bulk.
- n. Graphics
- i. The user interface shall display an equipment visualization or graphic within the context of its associated space (building, floor, room, etc.) or equipment dashboard.
  - ii. Graphics shall include the ability to define individual information layers for operator selection in order to clarify systems status and simplify operation on mobile devices. Where desired a master layer may be defined to include important information about the facility on all graphic screens.
  - iii. Graphics shall support the use of photo-realistic symbols as well as color change and animation to match the status of the related system control point.
  - iv. It shall be possible to export a time stamped .pdf file of the graphic being viewed in order to communicate the current conditions in the space or the equipment being viewed and to provide a historic record.

- v. An integral graphic manager shall be provided including the following features and capabilities:
- Creation and modification of graphics from any HTML5 capable browser without the need for additional plug-ins or software packages.
  - Access to a full suite of pre-defined templates for air and water sourced HVAC applications as well as the ability to add custom templates as created for other use. Pre-aliased graphic templates may be defined and saved for repetitive representations of common mechanical and electrical equipment.
  - A full suite of pre-defined three dimensional symbols for mechanical and electrical systems as well as all line, text and shape tools required for integration into a graphic with zoom and pan capabilities on multiple platforms and in multiple browsers.
  - The ability to search and replace items in multiple graphics with a single command.
  - The ability to import and insert photos and images into the graphic.
  - The ability of the graphics manager to create and edit graphics including the ability to bind graphic elements to the values and conditions of system points in both an on-line and off-line mode.
  - The ability to create and import custom SVG symbols that can be selectable from the graphical palette and rendered at runtime.
- vi. As required, the BMS Contractor shall provide software licenses in the name of the owner for programming, configuration and graphics building tools to allow designated representatives to make changes, modifications or additions to the system. While future updates or revisions may require an update fee, the owner shall incur no additional cost if they choose not to update. Systems that require any annual or time-limited licensing fees shall not be permitted.
- o. Scheduling
- i. The user interface shall provide the capability to display, in a singular view, all of the effective schedules in the context of the space (building/floor/room, etc.) or equipment that the schedule effects. The software should have the ability to display an effective schedule, for the present, or a future date.
  - ii. The user interface shall provide a report of all schedules affecting a space or equipment. The report shall provide the user details of events that comprise the weekly schedule and exception schedule(s). The report shall provide a means of viewing individual breakout scheduling elements for Weekly Schedule, Exceptions and Default Commands.
  - iii. The user interface shall provide the capability to efficiently change or modify schedules in mass quantities. This includes the capability to add, in bulk, exceptions to schedules, in addition to assigning, in bulk, weekly schedules.

## **SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC**

### **PART 1 - GENERAL**

#### **1.1 DEFINITIONS**

- A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.
- B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.
- C. BACnet Specific Definitions:
  - 1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data and services over a network.
  - 2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
  - 3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
  - 4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
- D. Binary: Two-state signal where a high signal level represents "ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.
- E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: network controllers, programmable application controllers, and application-specific controllers.
- F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.
- G. COV: Changes of value.
- H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.
- I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems to be capable of operating in a standalone mode using the last best available data.



- J. E/P: Voltage to pneumatic.
- K. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.
- L. HLC: Heavy load conditions.
- M. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI) and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.
- N. I/P: Current to pneumatic.
- O. LAN: Local area network.
- P. LNS: LonWorks Network Services.
- Q. LON Specific Definitions:
  - 1. FTT-10: Echelon Transmitter-Free Topology Transceiver.
  - 2. LonMark International: Association comprising suppliers and installers of LonTalk products. Association provides guidelines for implementing LonTalk protocol to ensure interoperability through a standard or consistent implementation.
  - 3. LonTalk: An open standard protocol developed by Echelon Corporation that uses a "Neuron Chip" for communication. LonTalk is a register trademark of Echelon.
  - 4. LonWorks: Network technology developed by Echelon.
  - 5. Node: Device that communicates using CTA-709.1-D protocol and that is connected to a CTA-709.1-D network.
  - 6. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number, and Node number. "Node number" portion of an address is a number assigned to device during installation, is unique within a subnet, and is not a factory-set unique Node ID.
  - 7. Node ID: A unique 48-bit identifier assigned at factory to each CTA-709.1-D device. Sometimes called a "Neuron ID."
  - 8. Program ID: An identifier (number) stored in a device (usually, EEPROM) that identifies node manufacturer, functionality of device (application and sequence), transceiver used, and intended device usage.
  - 9. Standard Configuration Property Type (SCPT): Pronounced "skip-it." A standard format type maintained by LonMark for configuration properties.
  - 10. Standard Network Variable Type (SNVT): Pronounced "snivet." A standard format type maintained by LonMark used to define data information transmitted and received by individual nodes. "SNVT" is used in two ways. It is an acronym for "Standard Network Variable Type" and is often used to indicate a network variable itself (i.e., it can mean "a network variable of a standard network variable type").

11. Subnet: Consists of a logical grouping of up to 127 nodes, where logical grouping is defined by node addressing. Each subnet is assigned a number, which is unique within a Domain. See "Node Address."
  12. TP/FT-10: Free Topology Twisted Pair network defined by CTA-709.3 and is most common media type for a CTA-709.1-D control network.
  13. TP/XF-1250: High-speed, 1.25 Mbps, twisted-pair, doubly terminated bus network defined by "LonMark Interoperability Guidelines" and typically used only to connect multiple TP/FT-10 networks.
  14. User-Defined Configuration Property Type (UCPT): Pronounced "u-keep-it." A Configuration Property format type that is defined by device manufacturer.
  15. User-Defined Network Variable Type (UNVT): Network variable format defined by device manufacturer. UNVTs create non-standard communications that other vendors' devices may not correctly interpret and may negatively impact system operation. UNVTs are not allowed.
- R. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- S. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.
- T. Modbus TCP/IP: An open protocol for exchange of process data.
- U. MS/TP: Master-slave/token-passing, ISO/IEC/IEEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.
- V. MTBF: Mean time between failures.
- W. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.
- X. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.
- Y. Peer to Peer: Networking architecture that treats all network stations as equal partners.
- Z. POT: Portable operator's terminal.
- AA. RAM: Random access memory.
- BB. RF: Radio frequency.
- CC. Router: Device connecting two or more networks at network layer.
- DD. Server: Computer used to maintain system configuration, historical and programming database.
- EE. TCP/IP: Transport control protocol/Internet protocol.

- FF. UPS: Uninterruptible power supply.
- GG. USB: Universal Serial Bus.
- HH. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.
- II. VAV: Variable air volume.
- JJ. WLED: White light emitting diode.

## **1.2 PREINSTALLATION MEETINGS**

- A. Preinstallation Conference: Conduct conference at Project site.

## **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of 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 effecting performance.
  - 5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
    - a. Workstations.
    - b. Printers.
    - c. Servers.
    - d. Gateways.
    - e. Routers.
    - f. Protocol analyzers.
    - g. DDC controllers.
    - h. Enclosures.
    - i. Electrical power devices.
    - j. UPS units.
    - k. Accessories.
    - l. Instruments.
    - m. Control dampers and actuators.
    - n. 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. Software Submittal:

1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
2. Description and technical data of all software provided and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Listing and description of each engineering equation used with reference source.
6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
7. Description of operator interface to alphanumeric and graphic programming.
8. Description of each network communication protocol.
9. Description of system database, including all data included in database, database capacity, and limitations to expand database.
10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden, and system throughout.
11. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

C. 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. Each desktop workstation network port, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
  - d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
  - e. Network communication cable and raceway routing.
  - f. Proposed routing of wiring, cabling, conduit, and tubing; coordinated with building services for review before installation.
- 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.
  - d. Each network port for connection of an operator workstation or other type of operator interface with unique identification 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.
10. Monitoring and control signal diagrams indicating the following:
  - a. Control signal cable and wiring between controllers and I/O.
  - b. Point-to-point schematic wiring diagrams for each product.
  - c. Control signal tubing to sensors, switches, and transmitters.
  - d. Process signal tubing to sensors, switches, and transmitters.
11. Color graphics indicating the following:
  - a. Itemized list of color graphic displays to be provided.
  - b. For each display screen to be provided, a true color copy showing layout of pictures, graphics, and data displayed.
  - c. Intended operator access between related hierarchical display screens.

D. System Description:

1. Project is an extension of the State of Missouri's existing control system. Contractor shall provide all the required components, wiring, sensors, valves, dampers, and programming to provide a complete and operational system as described in the project documents (specifications, drawings, and State of Missouri requirements).
2. See Section 230923-2 Addendum for additional information provided by Johnson Controls for additional control system requirements.
3. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
4. Complete listing and description of each report, log and trend for format and timing, and events that initiate generation.
5. System and product operation under each potential failure condition including, but not limited to, the following:
  - a. Loss of power.
  - b. Loss of network communication signal.
  - c. Loss of controller signals to inputs and outpoints.
  - d. Operator workstation failure.
  - e. Server failure.
  - f. Gateway failure.
  - g. Network failure.
  - h. Controller failure.
  - i. Instrument failure.
  - j. Control damper and valve actuator failure.

6. Complete bibliography of documentation and media to be delivered to Owner.
7. Description of testing plans and procedures.
8. Description of Owner training.

#### **1.4 INFORMATIONAL SUBMITTALS**

**A. Coordination Drawings:**

1. Plan drawings, reflected ceiling plans, or Building Information Model (BIM), and corresponding product installation details, drawn to scale, showing the items described in this Section and coordinated with all building trades.

**B. Product Certificates:**

1. Data Communications Protocol Certificates:
  - a. Certifying that each proposed DDC system component complies with ASHRAE 135.

**C. Test and Evaluation Reports:**

1. Product Test Reports: For DDC system equipment and components, for tests performed by a qualified testing agency.
2. Preconstruction Test Reports: For each separate test performed.

**D. Source Quality-Control Reports: For DDC system equipment and components.**

**E. Field Quality-Control Reports: For DDC system equipment and components.**

#### **1.5 CLOSEOUT SUBMITTALS**

**A. Operation and Maintenance Data: For DDC system.**

1. 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.

## **1.6 MAINTENANCE MATERIAL SUBMITTALS**

- A. Include product manufacturers' recommended parts lists for proper product operation over four-year period following warranty period. Parts list to be indicated for each year.
- B. Furnish parts, as indicated by manufacturer's recommended parts list, for product operation during one-year period following warranty period.

## **1.7 QUALITY ASSURANCE**

- A. DDC System Provider Qualifications:
  - 1. Authorized representative of, and trained by, DDC system manufacturer.
  - 2. Demonstrate past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
  - 3. Demonstrate past experience of each person assigned to Project.
  - 4. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
  - 5. Service and maintenance staff assigned to support Project during warranty period.



6. DDC system manufacturer's backing to take over execution of the Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.
- B. Testing Agency Qualifications: Member company of NETA.
  1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
- C. Welding Qualifications: Qualify procedures and personnel in accordance with the following welding codes:
  1. AWS D1.1/D1.1M.
  2. AWS D1.2/D1.2M.
  3. AWS D1.3/D1.3M.
  4. AWS D1.4/D1.4M.
- D. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators in accordance with ASME Boiler and Pressure Vessel Code.

## **1.8 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 8 hours of Owner's warranty service request.
  4. Warranty Period: Two-year(s) from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### **2.1 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.
  1. DDC system consisting of high-speed, peer-to-peer network of distributed DDC controllers, operator interfaces, and software.

- 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.

## **2.2 WEB ACCESS**

- A. DDC system to be .
  - 1. Web-Based Access to DDC System:
    - a. DDC system software based on server thin-client architecture, designed around open standards of web technology. DDC system server accessed using a web browser over DDC system network, using Owner's LAN, and remotely through Owner's LAN.
    - b. Intent of thin-client architecture is to provide operators complete access to DDC system via a web browser. No special software other than a web browser is required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
    - c. Password-protected web access.

## **2.3 SOURCE QUALITY CONTROL**

- A. Testing Agency: Engage a qualified testing agency to evaluate the following in accordance with industry standards for each product, and to verify DDC system reliability specified in performance requirements:
  - 1. DDC controllers.
  - 2. Gateways.
  - 3. Routers.
- B. Product(s) and material(s) will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

## **PART 3 - EXECUTION**

### **3.1 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.

### 3.2 **PREINSTALLATION INTEGRATION TESTING**

- A. Perform the following pretesting of other systems and equipment integration with DDC system before field installation:
  - 1. Test all communications in a controlled environment to ensure connectivity.
  - 2. Using simulation, demonstrate compliance with sequences of operation and other requirements indicated including, but not limited to, the following:
    - a. HVAC equipment controlled through DDC system, such as boilers, chillers, pumps, and air-handling units.
  - 3. Develop a method for testing interfaces before deployment.
  - 4. Submit documentation supporting compliance upon request.

### 3.3 **DDC SYSTEM INTERFACE WITH EXISTING SYSTEMS**

- A. Interface with Existing Systems:
  - 1. Interface DDC systems with existing systems to achieve integration indicated.
  - 2. Monitoring and Control of DDC System by Existing Control System:
    - a. Satisfy DDC system performance requirements when monitoring and controlling DDC system by existing control system.
    - b. Operator of existing system to upload, download, monitor, trend, control, and program every I/O point in DDC system from existing control system using existing control system software and operator workstations.
    - c. Make interface so operator of existing system is not required to learn new software for remote monitoring and control from existing control system.
    - d. Make interface of DDC system into existing control system transparent to operators of existing control system and allow operators to program, monitor, and control DDC system from any operator workstation connected to existing control system.

### **3.4 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS**

- A. Deliver all control devices, required by drawings and specifications to provide a complete and operational system to identified installers for field installation.

### **3.5 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 50-lb 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.

### **3.6 INSTALLATION OF WORKSTATIONS**

**A. Portable Workstation Installation:**

1. Install DDC system software on workstation(s) and verify that software functions properly.

**B. Color Graphics Application:**

1. Use system schematics indicated on Drawings as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Architect's review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Make final editing on-site with Owner's and Architect's review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

**C. Retractable, Wall-Mounted Cabinet for Portable Operator's Workstation Installation:**

1. Install retractable, wall-mounted portable operator's workstation cabinet(s) at location(s) indicated on Drawings.
2. Install retractable, wall-mounted portable operator's workstation cabinet(s) at following location(s) and at additional locations indicated on Drawings:
  - a. Each mechanical room.
  - b. Chiller room.
  - c. Boiler room.
3. Connect each cabinet to 120 V, single-phase, 60 Hz field power source and install single gang electrical box with NEMA WD 6, Type 20R duplex receptacle and metal cover plate in cabinet. Comply with requirements in Section 262726 "Wiring Devices."
4. Connect each cabinet to Ethernet network and install an Ethernet network port for connection to portable operator workstation Ethernet cable.

### **3.7 INSTALLATION OF CONTROLLERS**

- A. Install controllers in enclosures to comply with indicated requirements.
- B. Connect controllers to field power supply and to UPS units where indicated.
- 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.

### **3.8 NETWORK NAMING AND NUMBERING**

- A. Coordinate with Owner and provide unique naming and addressing for networks and devices.
- B. ASHRAE 135 Networks:
  - 1. MAC Address:
    - a. Assign and document a MAC address unique to its network for every network device.
    - b. Ethernet Networks: Document MAC address assigned at its creation.
    - c. MS/TP Networks: Assign from 00 to 64.
  - 2. Network Numbering:
    - a. Assign unique numbers to each new network.
    - b. Provide ability for changing network number through device switches or operator interface.
    - c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.
  - 3. Device Object Identifier Property Number:
    - a. Assign unique device object identifier property numbers or device instances for each device network.
    - b. Provide for future modification of device instance number by device switches or operator interface.
    - c. LAN is to support up to 4,194,302 unique devices.
  - 4. Device Object Name Property Text:
    - a. Device object name property field to support 32 minimum printable characters.
    - b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.
      - 1) Example 1: Device object name for device controlling heating water boiler plant at Building 1000 would be "Heating Water System Bldg. 1000."
      - 2) Example 2: Device object name for VAV terminal unit controller could be "VAV Unit 102."
  - 5. Object Name Property Text for Other Than Device Objects:
    - a. Object name property field is to support 32 minimum printable characters.
    - b. Assign object name properties with plain-English names descriptive of application.

- 1) Example 1: "Zone 1 Temperature."
- 2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:
  - a. Assign object identifier property numbers according to Drawings or tables indicated.
  - b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented, and be unique for like object types within device.

### **3.9 INSTALLATION OF CONTROL WIRE, CABLE, AND RACEWAY**

- A. Comply with NECA 1.
- B. Conduit Installation:
  1. Comply with Section 260533 "Raceways and Boxes for Electrical Systems" for control-voltage conductors.

### **3.10 FIELD QUALITY CONTROL**

- A. Testing Agency: 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 installations, including connections.
- C. Tests and Inspections: Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
  2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Testing of Air-Signal Tubing:
  1. Test for leaks and obstructions.
  2. Disconnect each pipe and tubing line before test is performed, and blowout dust, dirt, trash, condensate, and other foreign materials with compressed air. Use commercially pure compressed air or nitrogen as distributed in gas cylinders. Use of compressed air from oil-free compressor with air dryer is an acceptable alternative for test.
  3. After foreign matter is expelled and line is free from obstructions, plug far end of tubing run.
  4. Connect pressure source to near end of tubing run with needle valve between air supply and tubing run.

5. Connect pressure gauge accurate to within 0.5 percent of test between shutoff needle valve and tubing run under test.

E. Optical Fiber Cable Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. At a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Perform testing according to test plan supplied by DDC system manufacturer. Correct defective Work or material and retest. At a minimum, final testing for cable system, including spare cable, to verify compliance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use optical fiber time-domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

### **3.11 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. For pneumatic products, verify that air supply for each product is properly installed.
- F. Control Damper Checkout:
  1. For pneumatic control dampers, verify that pressure gauges are provided in each air line connected to the damper actuator and positioner.
  2. Verify that control dampers are installed correctly for flow direction.
  3. Verify that proper blade alignment, either parallel or opposed, has been provided.
  4. Verify that damper frame attachment is properly secured and sealed.
  5. Verify that damper actuator and linkage attachment are secure.
  6. Verify that actuator wiring is complete, enclosed, and connected to correct power source.



7. Verify that damper blade travel is unobstructed.

G. Control Valve Checkout:

1. For pneumatic control valves, verify that pressure gauges are provided in each air line connected to the valve actuator and positioner.
2. Verify that control valves are installed correctly for flow direction.
3. Verify that valve body attachment is properly secured and sealed.
4. Verify that valve actuator and linkage attachment are secure.
5. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
6. Verify that valve ball, disc, or plug travel is unobstructed.
7. 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.

H. 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.

### **3.12 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. 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.
- E. Calibrate each instrument in accordance with instruction manual supplied by instrument manufacturer.
- F. If after calibration the indicated performance cannot be achieved, replace out-of-tolerance instruments.
- G. 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.
- H. Digital Signals:
  1. Check digital signals using a jumper wire.
  2. Check digital signals using an ohmmeter to test for contact making or breaking.
- I. 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 seconds.
  4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
- J. 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 seconds.
  4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
- K. Meters: Check meters at zero, 50, and 100 percent of Project design values.
- L. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
- M. Switches: Calibrate switches to make or break contact at set points indicated.

N. 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.

**3.13 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.

**3.14 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 desired results.

### **3.15 DDC SYSTEM VALIDATION TESTS**

- A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.
- B. After approval of Pretest Checklist and Test Plan, execute all tests and procedures indicated in plan.
- C. After testing is complete, submit completed Pretest Checklist.
- D. Pretest Checklist: Submit the following list with items checked off once verified:
  1. Detailed explanation for any items that are not completed or verified.
  2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
  3. HVAC equipment motors operate below full-load amperage ratings.
  4. Required DDC system components, wiring, and accessories are installed.
  5. Installed DDC system architecture matches approved Drawings.
  6. Control electric power circuits operate at proper voltage and are free from faults.
  7. Required surge protection is installed.
  8. DDC system network communications function properly, including uploading and downloading programming changes.
  9. Using BACnet protocol analyzer, verify that communications are error free.
  10. Each controller's programming is backed up.
  11. Testing, adjusting, and balancing work affecting controls is complete.
  12. Dampers and actuators zero and span adjustments are set properly.
  13. Each control damper and actuator goes to failed position on loss of power and loss of signal.
  14. Valves and actuators zero and span adjustments are set properly.
  15. Each control valve and actuator goes to failed position on loss of power and loss of signal.
  16. Meter, sensor, and transmitter readings are accurate and calibrated.
  17. View trend data where applicable.
  18. Each controller works properly in standalone mode.
  19. Safety controls and devices function properly.
  20. Interfaces with fire-alarm system function properly.
  21. Electrical interlocks function properly.
  22. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphics are created.
  23. Record Drawings are completed.
- E. Test Plan:

1. Prepare and submit validation Test Plan including test procedures for performance validation tests.
2. Address all specified functions of DDC system and sequences of operation in Test Plan.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include Test Checklist to be used to check and initial that each test has been successfully completed.
6. Submit Test Plan documentation business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.
  - a. Verify analog I/O points at operating value.
  - b. Make adjustments to out-of-tolerance I/O points.
    - 1) Identify I/O points for future reference.
    - 2) Simulate abnormal conditions to demonstrate proper function of safety devices.
    - 3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.
2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
5. After validation testing is complete, prepare and submit report indicating results of testing. For all I/O points that required correction, indicate how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. DDC System Response Time Test:

1. Simulate HLC.
  - a. Heavy load to be occurrence of percent of total connected binary COV, one-half of which represents "alarm" condition, and percent of total connected analog COV, one-half of which represents "alarm" condition, that are initiated simultaneously on a one-time basis.
2. Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.
3. Measure with timer having at least 0.1-second resolution and 0.01 percent accuracy.
4. Passing test is contingent on the following:

- a. All alarms, both binary and analog, are reported and printed; none are lost.
  - b. Compliance with response times specified.
5. Prepare and submit report documenting HLC tested and results of test including time stamp and print out of all alarms.
- H. DDC System Network Bandwidth Test:
  1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
  2. To pass, none of DDC system networks are to use more than 70 percent of available bandwidth under normal and HLC operation.

### **3.16 FINAL REVIEW**

- A. Submit written request to Architect and Owner when DDC system is ready for final review. State the following:
  1. DDC system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
  2. DDC system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
  3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
  4. DDC system is complete and ready for final review.
- B. Upon receipt of written request for final review, Architect and Owner to start review within reasonable period and upon completion issue field report(s) documenting observations and deficiencies.
- C. Take prompt action to remedy deficiencies indicated in reviewer's field report(s) and submit second written request after all deficiencies have been corrected. Repeat process until no deficiencies are reported.
- D. Compensation for Subsequent Reviews: Should more than two reviews be required, DDC system manufacturer and Installer to compensate entity/entities performing reviews for total costs (labor and expenses) associated with subsequent reviews. Estimated cost of each subsequent review to be submitted and approved by DDC system manufacturer and Installer before review.
- E. Prepare and submit closeout submittals and begin procedures indicated in "Extended Operation Test" Article when no deficiencies are reported.
- F. Part of DDC system final review to include demonstration to parties participating in final review.

1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
3. Demonstration to include, but not be limited to, the following:
  - a. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to I/O points to be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
  - b. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
  - c. Operation of randomly selected dampers and valves in normal-on, normal-off, and failed positions.
  - d. Trends, summaries, logs, and reports set up for Project.
  - e. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
  - f. Software's ability to communicate with controllers, operator workstations, and uploading and downloading of control programs.
  - g. Software's ability to edit control programs offline.
  - h. Data entry to show Project-specific customizing capability including parameter changes.
  - i. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
  - j. Execution of digital and analog commands in graphic mode.
  - k. Spreadsheet and curve plot software and its integration with database.
  - l. Online user guide and help functions.
  - m. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.
  - n. System speed of response compared to requirements indicated.
  - o. For Each Controller: Applies to controllers.
    - 1) Memory: Programmed data, parameters, trend, and alarm history collected during normal operation are not to be lost during power failure.
    - 2) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
    - 3) Wiring Labels: Match control drawings.
    - 4) Network Communication: Ability to locate controller's location on network and communication architecture matches Shop Drawings.
    - 5) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.
  - p. For Each Operator Workstation:
    - 1) I/O points lists agree with naming conventions.

- 2) Graphics are complete.

### **3.17 EXTENDED OPERATION TEST**

- A. Operate DDC system for operating period of consecutive calendar days following Substantial Completion. Coordinate exact start date of testing with Owner.
- B. Provide operator familiar with DDC system installed to man an operator workstation while on-site during eight hours of each normal business day occurring during operating period.
- C. During operating period, DDC system to demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.
  1. Correct defects of hardware and software when they occur.
- D. Definition of Failures and Downtime during Operating Period:
  1. Failed I/O point constituting downtime is I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.
  2. Downtime is when any I/O point in DDC system is unable to fulfill its required function.
  3. Calculate downtime as elapsed time between detected point failure as confirmed by operator, and time point is restored to service.
  4. Maximum time interval allowed between DDC system detection of failure occurrence and operator confirmation is to be 0.5 hours.
  5. Log downtime in hours to nearest 0.1 hour.
  6. Hardware or software failures caused by power outages do count as downtime.
- E. During operating period, log downtime and operational problems are encountered.
  1. Identify source of problem.
  2. Provide written description of corrective action taken.
  3. Record duration of downtime.
  4. Maintain log showing the following:
    - a. Time of occurrence.
    - b. Downtime for each failed I/O point.
    - c. Running total of downtime and total time of I/O point after each problem has been restored.
  5. Make log available to Owner for review at any time.
- F. For DDC system to pass extended operation test, total downtime is limited to percent of total point-hours during operating period.
  1. If DDC system testing results fail to comply with minimum requirements of passing at end of operating period indicated, extend operating period one consecutive day at a time until DDC system passes requirement.



- G. Base evaluation of DDC system passing test on the following calculation:
1. Count downtime on point-hour basis where total number of DDC system point-hours is equal to total number of I/O points in DDC system multiplied by total number of hours during operating period.
  2. Example Calculation: Maximum allowable downtime for 30-day test for DDC system with 1000 total I/O points (combined analog and binary) and passing score of 1 percent downtime is computed by 30 days x 24 h/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.
- H. Prepare test and inspection reports.

### **3.18 ADJUSTING**

- A. Occupancy Adjustments: When requested within four full seasons 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.

### **3.19 SOFTWARE SERVICE AGREEMENT**

- A. Technical Support: Beginning at Substantial Completion, verify that service agreement includes software support for year(s).
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within year(s) from date of Substantial Completion. Verify that upgrading software includes operating system and new or revised licenses for using software.
1. Upgrade Notice: No fewer than days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

### **3.20 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.
- B. Extent of Training:
1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
  2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
  3. Minimum Training Requirements:

- a. Provide not less than days of training total.
  - b. Stagger training over multiple training classes to accommodate Owner's requirements. All training to occur before end of warranty period.
  - c. Break down total days of training into not more than separate training classes.
  - d. Schedule training so each training class is not less than consecutive day(s).
- C. Attendee Training Manuals:
  1. Provide each attendee with color hard copy of all training materials and visual presentations.
  2. Organize hard-copy materials in three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
  3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes DVD or flash drive with PDF copy of all hard-copy materials.
- D. Instructor Requirements:
  1. Use instructors who have provided not less than years of instructional training on not less than past projects with similar DDC system scope and complexity to DDC system installed.
- E. Organization of Training Sessions:
  1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:
    - a. Advanced operators.
    - b. System managers and administrators.
  2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions to ensure DDC system security.
- F. On-Site Training:
  1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
  2. Provide training materials, projector, and other audiovisual equipment used in training.
  3. Provide as much of training located on-site as deemed feasible and practical by Owner.
  4. Include on-site training with regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
  5. Use operator workstation that is to be used with DDC system in the training. If operator workstations are unavailable, provide temporary workstation to convey training content.
- G. Video of Training Sessions:

General Headquarters Complex  
Renovations to Interior/Exterior & Install Emergency Generator  
Multiple Assets  
Jefferson City, MO

State Project Number: R2502-01

1. Provide digital video and audio recording of each training session. Create separate recording file for each session.
2. Stamp each recording file with training session number, session name, and date.
3. Provide Owner with two copies of digital files on cloud and flash drives for later reference and for use in future training.
4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

**END OF SECTION**

## **SECTION 230923.11 - CONTROL VALVES**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Butterfly-style control valves.
  - 2. Pressure-independent control valves.
  - 3. Electric and electronic control valve actuators.

#### **1.2 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.

#### **1.3 ACTION SUBMITTALS**

- A. Product Data:
  - 1. Butterfly-style control valves.
  - 2. Pressure-independent control valves.
  - 3. Electric and electronic control valve actuators.
- B. 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.

C. 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.
4. Include diagrams for pneumatic signal and main air tubing.

## 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are indicated and coordinated with each other, using input from installers of the items involved:
1. Control valve installation location indicated in relationship to room, duct, pipe, and equipment.
  2. Size and location of wall access panels for control valves installed behind walls.
  3. Size and location of ceiling access panels for control valves installed above inaccessible ceilings.

## 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For control valves.

## PART 2 - PRODUCTS

### 2.1 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. Backup Power Source: Serve control valve 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. Suitable for operation throughout full range of system operating conditions encountered.
    - a. Combined Two Pipe Heating and Chilled Water: minus 20°F to plus 220°F, 125 psi.
    - b. Condenser Water: minus 20°F to plus 150°F, 100 psi.
  - 2. Control Valve Leakage: FCI 70-2, Class IV or less leakage, unless otherwise indicated.
  - 3. Control Valve Pattern: as indicated on Drawings.
  - 4. Control Valve Flow Characteristics, Unless Otherwise Indicated:
    - a. Modulating, Two-Way Pattern: Equal percentage.
    - b. Modulating Three-Way Pattern: Linear flow. Total flow through the valve to be constant regardless of the valve's position.
  - 5. Fail-Safe Positions, Unless Otherwise Indicated:
    - a. Combined Two Pipe Heating and Chilled Water: Open.
    - b. Condenser Water: Last position.
  - 6. Stable Operation: Select control valves and actuators for stable operation throughout full range of operation, from design Cv at design flow to minimum Cv.
  - 7. Control Valve Styles:
    - a. Hydronic Systems:
      - 1) Pipe Sizes NPS 2 and Smaller: Ball-style control valves.
      - 2) Pipe Sizes Larger than NPS 2: Ball-style control valves.
- I. Sizing Criteria: Unless otherwise indicated, select control valve size using the following:
  - 1. ISA Standards:

- a. Control Valve Sizes and Flow Coefficients: ISA 75.01.01.
  - b. Control Valve Characteristics and Rangeability: ISA 75.11.01.
2. Correction Factors: Consider viscosity, flashing, and cavitation corrections when selecting control valves.
3. Ball-Style Control Valves: Select valve size with design Cv at design flow between 65 and 75 degrees of valve full open position and minimum Cv between 15 and 25 percent of open position.
4. Butterfly-Style Control Valves: Select valve size with design Cv at design flow between 65 and 75 degrees of valve full open position and minimum Cv between 15 and 25 percent of open position.
5. Modulating Control Valves in Hydronic Systems:
  - a. Select modulating control valve sizes at terminal equipment for a design Cv based on a pressure drop of 5 psig at design flow.
  - b. Calculate control valve minimum Cv at 10 percent of control valve design flow, with a coincident pressure differential equal to the system design pump head.
6. Two-Position Valves: Select two-position control valves for full pipeline size.

## **2.2 BUTTERFLY-STYLE CONTROL VALVES**

- A. High-Performance Butterfly Valves, Two Way:
  1. Source Limitations: Obtain two-way high-performance butterfly valves from single manufacturer.
  2. Performance:
    - a. Stem Action: Rotary, 0 to 90 degrees.
    - b. Flow Characteristic: Linear or modified equal percentage.
    - c. Leakage: FCI 70-2, Class VI.
    - d. Hydronic Pressure:
      - 1) Rating: ASME B16.34, Class 150.
    - e. Hydronic Process Temperature Rating: Minus 20 to plus 450 deg F.
    - f. Rangeability: 100 to 1.
  3. Standards: ASME B16.34, MSS SP-68.
  4. Features:
    - a. Bidirectional, end-of-line service.
    - b. Extended neck of body to accommodate up to 2-inch- thick insulation.
    - c. Replaceable seat, disc and shaft bearings/bushings.
  5. Construction:

- a. Body: Cast steel; single flange, fully lugged and suitable for mating to ASME B16.5 or ASME B16.47 flanges.
- b. Disc: Stainless steel.
- c. Seat: Reinforced PTFE with stainless steel retaining ring.
- d. Stem(s): Stainless steel.
- e. Stem Bearings: Stainless steel.
- f. Stem Packing: PTFE.
- g. Corrosion-resistant nameplate indicating the following:
  - 1) Manufacturer's name, model number, and serial number.
  - 2) Body size.
  - 3) Body and trim materials.
  - 4) Body rating.
  - 5) Arrow indicating direction of flow.

## 2.3 **PRESSURE-INDEPENDENT CONTROL VALVES**

### A. Pressure-Independent Ball Valves NPS 2-1/2 to NPS 6:

1. Source Limitations: Obtain pressure-independent ball valves NPS 2-1/2 to NPS 6 from single manufacturer.
2. Performance:
  - a. Stem Action: Rotary, 0 to 90 degrees.
  - b. Flow Characteristic: Equal percentage.
  - c. Leakage: Zero.
  - d. Hydronic Pressure Rating: In accordance with ASME B16.1, Class 125 or 250, as required by application.
  - e. Hydronic Close-off Pressure:
    - 1) Class 125: 175 psig.
  - f. Process Temperature Range: Between 35 to 250 deg F.
  - g. Rangeability: 100 to 1.
3. Pressure Regulation: Control valve automatically adjusts to fluctuations in system pressure by one of the follow methods:
  - a. Integral Mechanical Regulation: Maintains a constant pressure differential while operating within a pressure differential range of 5 to 50 psig.
  - b. Integral Electronic Regulation: Electronic flow meter and control signal to maintain flow set point regardless of system pressure variations and modulates valve based on its measured true flow.
    - 1) Flow Measurement: Within 2 percent of actual reading.
    - 2) Flow Control: Within 5 percent of set point.
    - 3) Pressure Differential Range: 5 to 50 psig.



4. Construction:
  - a. Body: Cast iron; ASME B16.1.
  - b. End Connections: Flanged; suitable for mating to ASME B16.5 flanges.
  - c. Test Ports: Two pressure and temperature test ports positioned on valve body to read pressure differential.
  - d. Ball: Stainless steel.
  - e. Seats: RTFE.
  - f. Stem and Stem Extension: Material to match ball; blowout-proof design.
  - g. Stem Seal: Reinforced PTFE packing ring stem seal with 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 equivalent cycle endurance can be achieved.

## **2.4 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS**

- A. Actuators for Control Valves in Hydronic Systems: Select actuators to close off against system pump shutoff head.
- B. Type: Motor operated, with or without gears, electric and electronic.
- C. Voltage:
  1. Actuator to deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
  2. Actuator to function properly within a range of 85 to 120 percent of nameplate voltage.
- D. Local Manual Override: Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.
- E. Modulating Actuators:
  1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
  2. Control Input Signal:
    - a. Proportional: Actuator drives proportionally to input signal, modulates throughout its angle of rotation, and is suitable for zero to 10 V dc signals.
- F. Position Feedback:
  1. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
  2. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.
- 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 nonmechanical 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. Valve Attachment:

1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve stem 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.

J. Enclosure:

1. Suitable for ambient conditions encountered by application.

K. Stroke Time:

1. Select operating stroke time to be compatible with equipment and system operation, and as follows:
  - a. Operate valve from fully closed to fully open position within 150 seconds.
  - b. Operate valve from fully open to fully closed position within 150 seconds.
  - c. Move valve to fail-safe position within 15 seconds.

## **PART 3 - EXECUTION**

### **3.1 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.

### **3.2 CONTROL VALVE APPLICATIONS**

- A. Control Valves:
  - 1. Select from valves specified in "Control Valves" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

### **3.3 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 other 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.

### **3.4 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. Drain Valves:

1. Install drain valves in piping upstream and downstream of each control valve larger than NPS 4.
  2. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold.
- D. Test Plugs: Install pressure temperature test plugs in piping upstream and downstream of each control valve.
- E. 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.
- F. 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.
- G. 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.
- H. Flanged Valves:
1. Align flange surfaces parallel.
  2. Assemble joints by sequencing bolt-tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

### **3.5 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."
- B. Install valve identification in accordance with requirements in Section 230553 "Identification for HVAC Piping and Equipment".

### **3.6 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".
- 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 "Raceway and Boxes 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."
  - 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

### **3.7 CONTROL CONNECTIONS**

- A. Pneumatic Control Connections: Connect pneumatic control valve actuators and accessories to pneumatic main and signal air. 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 260533 "Raceway and Boxes for Electrical Systems."

### **3.8 CLEANING**

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

### **3.9        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.    For pneumatic products, verify air supply for each product is properly installed.
5.    For pneumatic valves, verify that pressure gauges are provided in each air line to valve actuator and positioner.
6.    Verify that control valves are installed correctly for flow direction.
7.    Verify that valve body attachment is properly secured and sealed.
8.    Verify that valve actuator and linkage attachment are secure.
9.    Verify that actuator wiring is complete, enclosed, and connected to correct power source.
10.   Verify that valve ball, disc, and plug travel are unobstructed.
11.   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.

### **3.10      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.    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.
- C.    Check and document open and close cycle times.
- D.    For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

### **END OF SECTION**

## **SECTION 230993.11 - SEQUENCE OF OPERATIONS FOR HVAC DDC**

### **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 control sequences for DDC for HVAC systems, subsystems, and equipment.

#### **1.3 DEFINITIONS**

- A. Analog Output: Proportional output signal (zero- to 10-V dc, 4 to 20 mA).
- B. Binary Output: On/off output signal or contact closure.
- C. DDC: Direct digital control.
- D. Digital Output: Data output that must be interpreted digitally.

#### **1.4 ACTION SUBMITTALS**

- A. Product Data:
  - 1. An instrumentation list for each controlled system. Label each element of the controlled system in table format. Show, in the table element name, type of device, manufacturer, model number, and control device product data sheet number.
  - 2. A complete description of the operation of the control system, including sequences of operation. Include and reference a schematic diagram of the controlled system.
- B. Shop Drawings:
  - 1. Riser diagrams showing control network layout, communication protocol, and wire types.
  - 2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
  - 3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

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## **1.5 SEQUENCES OF OPERATION**

- A. See sequences of operation and points lists on associated drawings.

## **PART 2 - PRODUCTS (Not Applicable)**

## **PART 3 - EXECUTION (Not Applicable)**

## **END OF SECTION**



## **SECTION 231123 - FACILITY NATURAL-GAS PIPING**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Pipes, tubes, and fittings.
  - 2. Manual gas shutoff valves.
  - 3. Motorized gas valves.
  - 4. Earthquake valves.
  - 5. Pressure regulators.
  - 6. Service meters.
  - 7. Dielectric fittings.

#### **1.2 DEFINITIONS**

- A. CWP: Cold working pressure.
- B. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. An example includes rooftop locations.
- C. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- D. 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.

#### **1.3 ACTION SUBMITTALS**

- A. Product Data:
  - 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.
  - 5. Service meters. Indicate pressure ratings and capacities.
  - 6. Dielectric fittings.

- B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
  - 1. Shop Drawing Scale: 1/4 inch per foot.
  - 2. Detail mounting, supports, and valve arrangements for service-meter assembly and pressure regulator assembly.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.
- B. Welding certificates.
- C. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.
- D. Field quality-control reports.
- E. Qualification Statements: For professional engineer.

#### **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For motorized gas valves pressure regulators service meters to include in emergency, operation, and maintenance manuals.

#### **1.6 QUALITY ASSURANCE**

- A. Steel Support Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators in accordance with the ASME Boiler and Pressure Vessel Code.

#### **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping in accordance with 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.
- D. Protect stored PE pipes and valves from direct sunlight.

## **1.8 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 in accordance with requirements indicated:
  - 1. Notify Owner no fewer than seven days in advance of proposed interruption of natural-gas service AND again one day in advance.
  - 2. Do not proceed with interruption of natural-gas service without Owner's written permission.

## **1.9 COORDINATION**

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate requirements for access panels and doors for valves installed and concealed behind finished surfaces. Comply with requirements in Section 083113 "Access Doors and Frames."
- C. Coordinate requirements for piping identification for natural-gas piping. Comply with requirements in Section 220553 "Identification of Plumbing Piping and Equipment."

## **PART 2 - PRODUCTS**

### **2.1 SOURCE LIMITATIONS**

- A. Obtain each product type from single source from single manufacturer.

### **2.2 PERFORMANCE REQUIREMENTS**

- A. Comply with the International Fuel Gas Code.
- 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. Seismic Performance: Natural-gas piping system is to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.

1. The term "withstand" means "the piping system will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the piping system will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

## **2.3 PIPES, TUBES, AND FITTINGS**

### **A. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.**

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. 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.
5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
  - a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

### **B. Drawn-Temper Copper Tube: Comply with ASTM B837, Type G.**

1. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
2. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
  - a. Gasket Material: ASME B16.20, metallic, flat, asbestos free, aluminum O-rings, and spiral-wound metal gaskets.
  - b. Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel.
3. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of 0.022 inch thick.

### **C. Annealed-Temper Copper Tube: Comply with ASTM B837, Type G.**

1. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
2. Flare Fittings: Comply with ASME B16.26 and SAE J513.
  - a. Copper fittings with long nuts.

- b. Metal-to-metal compression seal without gasket.
  - c. Dryseal threads complying with ASME B1.20.3.
- 3. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of 0.022 inch thick.

## **2.4 PIPING SPECIALTIES**

### **A. Appliance Flexible Connectors:**

- 1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
- 2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
- 3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
- 4. Corrugated, stainless steel tubing with polymer coating.
- 5. Operating-Pressure Rating: 0.5 psig.
- 6. End Fittings: Zinc-coated steel.
- 7. Threaded Ends: Comply with ASME B1.20.1.
- 8. Maximum Length: 72 inches.

### **B. 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: 40 60-mesh startup strainer, and perforated stainless steel basket with 50 percent free area.
- 4. CWP Rating: 125 psig.

### **C. Weatherproof Vent Cap:**

- 1. Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

## **2.5 JOINING MATERIALS**

- A. Joint Compound and Tape: Suitable for natural gas.
- B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

## 2.6 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. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
  4. Tamperproof Feature: Locking feature for valves indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
  5. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
  6. Service Mark: Valves NPS 1-1/4 to NPS 2 having 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. Tamperproof Feature: Locking feature for valves indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
  4. Service Mark: Initials "WOG" permanently marked on valve body.
- C. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
1. Body: Bronze, complying with ASTM B584.
  2. Ball: Chrome-plated brass.
  3. Stem: Bronze; blowout proof.
  4. Seats: Reinforced TFE; blowout proof.
  5. Packing: Separate packnut with adjustable-stem packing threaded ends.
  6. Ends: Threaded, flared, or socket as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
  7. CWP Rating: 600 psig.
  8. Listing: Valves NPS 1 and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Body: Bronze, complying with ASTM B584.
  2. Ball: Chrome-plated bronze.
  3. Stem: Bronze; blowout proof.
  4. Seats: Reinforced TFE; blowout proof.
  5. Packing: Threaded-body packnut design with adjustable-stem packing.
  6. Ends: Threaded, flared, or socket as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
  7. CWP Rating: 600 psig.

8. Listing: Valves NPS 1 and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- E. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Body: Bronze, complying with ASTM B584.
  2. Ball: Chrome-plated bronze.
  3. Stem: Bronze; blowout proof.
  4. Seats: Reinforced TFE.
  5. Packing: Threaded-body packnut design with adjustable-stem packing.
  6. Ends: Threaded, flared, or socket as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
  7. CWP Rating: 600 psig.
  8. Listing: Valves NPS 1 and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- F. Bronze Plug Valves: MSS SP-78.
1. Body: Bronze, complying with ASTM B584.
  2. Plug: Bronze.
  3. Ends: Threaded, socket, or flanged as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
  4. Operator: Square head or lug type with tamperproof feature where indicated.
  5. Pressure Class: 125 psig.
  6. Listing: Valves NPS 1 and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  7. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- G. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.
1. Body: Cast iron, complying with ASTM A126, Class B.
  2. Plug: Bronze or nickel-plated cast iron.
  3. Seat: Coated with thermoplastic.
  4. Stem Seal: Compatible with natural gas.
  5. Ends: Threaded or flanged as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
  6. Operator: Square head or lug type with tamperproof feature where indicated.
  7. Pressure Class: 125 psig.
  8. Listing: Valves NPS 1 and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- H. Cast-Iron, Lubricated Plug Valves: MSS SP-78.
1. Body: Cast iron, complying with ASTM A126, Class B.
  2. Plug: Bronze or nickel-plated cast iron.
  3. Seat: Coated with thermoplastic.

4. Stem Seal: Compatible with natural gas.
5. Ends: Threaded or flanged as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
6. Operator: Square head or lug type with tamperproof feature where indicated.
7. Pressure Class: 125 psig.
8. Listing: Valves NPS 1 and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

I. Valve Boxes:

1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

## 2.7 MOTORIZED GAS VALVES

A. Automatic Gas Valves: Comply with ANSI Z21.21.

1. Body: Brass or aluminum.
2. Seats and Disc: NBR.
3. Springs and Valve Trim: Stainless steel.
4. Normally closed.
5. Visual position indicator.
6. Electrical Mechanical actuator operated by appliance automatic shutoff device.

B. Electrically Operated Valves: Comply with UL 429.

1. Pilot operated.
2. Body: Brass or aluminum.
3. Seats and Disc: NBR.
4. Springs and Valve Trim: Stainless steel.
5. 120 V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
6. NEMA ICS 6, Type 4, coil enclosure.
7. Normally closed.
8. Visual position indicator.

## 2.8 EARTHQUAKE VALVES

A. Earthquake Valves, Maximum Operating Pressure of 5 psig: Comply with ASCE/SEI 25.

1. Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
2. Maximum Operating Pressure: 5 psig.
3. Cast-aluminum body with nickel-plated chrome steel internal parts.



4. NBR valve washer.
5. Sight windows for visual indication of valve position.
6. Threaded end connections complying with ASME B1.20.1.
7. Wall-mounting bracket with bubble level indicator.

## **2.9 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. Service Pressure Regulators: Comply with ANSI Z21.80A.**

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: NBR; resistant to gas impurities, abrasion, and deformation at the valve port.
5. Orifice: Aluminum; interchangeable.
6. Seal Plug: UV-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 regulator.
8. Pressure regulator is to maintain discharge pressure setting downstream and is to 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: 100 psig Insert pressure.

### **C. Line Pressure Regulators: Comply with ANSI Z21.80A.**

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: NBR; resistant to gas impurities, abrasion, and deformation at the valve port.
5. Orifice: Aluminum; interchangeable.
6. Seal Plug: UV-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 regulator.
8. Pressure regulator is to maintain discharge pressure setting downstream and is to 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: 2 psig 5 psig 10 psig Insert pressure.

D. 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: NBR.
5. Seal Plug: UV-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: 1 psig 2 psig 5 psig Insert pressure.

**2.10 SERVICE METERS**

A. Diaphragm-Type Service Meters: Comply with ANSI B109.1 ANSI B109.2.

1. Case: Die-cast aluminum.
2. Connections: Steel threads.
3. Diaphragm: Synthetic fabric.
4. Diaphragm Support Bearings: Self-lubricating.
5. Compensation: Continuous temperature and pressure.
6. Meter Index: Cubic feet liters.
7. Meter Case and Index: Tamper resistant.
8. Remote meter reader compatible.
9. Maximum Inlet Pressure: 100 psig.
10. Pressure Loss: Maximum 0.5 inch wg 2.0 inch wg Insert pressure differential.
11. Accuracy: Maximum plus or minus 1.0 percent.

B. Rotary-Type Service Meters: Comply with ANSI B109.3.

1. Case: Extruded aluminum.
2. Connection: Flange.
3. Impellers: Polished aluminum.
4. Rotor Bearings: Self-lubricating.
5. Compensation: Continuous temperature and pressure.
6. Meter Index: Cubic feet liters.
7. Tamper resistant.
8. Remote meter reader compatible.
9. Maximum Inlet Pressure: 100 psig.
10. Accuracy: Maximum plus or minus 2.0 percent.

C. Turbine Meters: Comply with ASME MFC-4M.

1. Housing: Cast iron or welded steel.
2. Connection Threads or Flanges: Steel.
3. Turbine: Aluminum or plastic.
4. Turbine Bearings: Self-lubricating.
5. Compensation: Continuous temperature and pressure.

6. Meter Index: Cubic feet liters.
7. Tamper resistant.
8. Remote meter reader compatible.
9. Maximum Inlet Pressure: 100 psig.
10. Accuracy: Maximum plus or minus 2.0 percent.

D. Service-Meter Bars:

1. Malleable- or cast-iron frame for supporting service meter.
2. Include offset swivel pipes, meter nuts with O-ring seal, and factory- or field-installed dielectric unions.
3. Omit meter offset swivel pipes if service-meter bar dimensions match service-meter connections.

E. Service-Meter Bypass Fittings:

1. Ferrous, tee, pipe fitting with capped side inlet for temporary natural-gas supply.
2. Integral ball-check bypass valve.

## **2.11 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: 125 psig minimum at 180 deg F 150 psig 250 psig Insert pressure.
  - 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: 125 psig minimum at 180 deg F 150 psig 175 psig 300 psig Insert pressure.
  - 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.

## **2.12 LABELING AND IDENTIFYING**

- A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description and rated pressure of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.
- B. Label and identify gas piping and pressure outside a multitenant building by tenant.

## **PART 3 - EXECUTION**

### **3.1 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.

### **3.2 PREPARATION**

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping in accordance with 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 preventing accidental ignition.

### **3.3 INSTALLATION OF OUTDOOR PIPING**

- A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.
  - 1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.
- C. Install underground, PE, natural-gas piping in accordance with ASTM D2774.

- D. Steel Piping with Protective Coating:
  - 1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
  - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
  - 3. Replace pipe having damaged PE coating with new pipe.
- E. Copper Tubing with Protective Coating:
  - 1. Apply joint cover kits over tubing to cover, seal, and protect joints.
  - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
- F. Install fittings for changes in direction and branch connections.
- G. Install pressure gauge upstream and downstream from each service regulator. Pressure gauges are specified in Section 230500 "Common Work Results for HVAC."

### **3.4 INSTALLATION OF INDOOR PIPING**

- 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. Do not install piping in concealed locations unless sleeved with the sleeve open at both ends.
- 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. Where installing piping above accessible ceilings, allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access. Do not locate valves within return air plenums.
- 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.
  - 2. Install sediment trap on both sides of regulators for gas reduction to 2 psig with valve and 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 and automatic or electrically operated valve.
- V. Install pressure gauge upstream and downstream from each line regulator. Pressure gauges are specified in Section 230500 "Common Work Results for HVAC."
- W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Common Work Results for HVAC."
- X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230500 "Common Work Results for HVAC."
- Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC."

### **3.5 INSTALLATION OF SERVICE-METER ASSEMBLIES**

- A. Install service-meter assemblies aboveground, on concrete bases.
- B. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.
- C. Install strainer on inlet of service-pressure regulator and meter set.
- D. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.
- E. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.
- F. Install service meters downstream from pressure regulators.
- G. Install metal bollards to protect meter assemblies. Comply with requirements in Section 055000 "Metal Fabrications" for pipe bollards.

### **3.6 INSTALLATION OF VALVES**

- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless steel tubing, aluminum, or copper connector.
- B. Install underground valves with valve boxes.

- C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- D. Install earthquake valves aboveground outside buildings according to listing.
- E. Install anode for metallic valves in underground PE piping.
- F. Do not install valves in return-air plenums.

### **3.7 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. Welded Joints:
  - 1. Construct joints in accordance with AWS D10.12/D10.12M, using qualified processes and welding operators.
  - 2. Bevel plain ends of steel pipe.
  - 3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
- E. Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
- F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.
- G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, and then use wrench. Do not overtighten.
- H. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join in accordance with ASTM D2657.
  - 1. Plain-End Pipe and Fittings: Use butt fusion.



2. Plain-End Pipe and Socket Fittings: Use socket fusion.

### **3.8 INSTALLATION OF HANGERS AND SUPPORTS**

- A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- C. Install hangers for steel and 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. Install hangers for corrugated stainless steel tubing, 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.
- E. Support horizontal piping within 12 inches of each fitting.
- F. Support vertical runs of steel and copper tubing to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

### **3.9 PIPING 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 in accordance with NFPA 70.
- C. Where installing piping adjacent to appliances, allow space for 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.

### **3.10 LABELING AND IDENTIFICATION**

- A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.
- B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

### **3.11 CONCRETE BASES**

- A. Concrete Bases: Anchor equipment to concrete base in accordance with seismic codes at Project. See Section 230548 "Vibration and Seismic Controls for HVAC."
  - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
  - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
  - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
  - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - 6. Use 3000 psig, 28-day, compressive-strength concrete and reinforcement as specified in Section 033000 "Cast-in-Place Concrete."

### **3.12 FIELD QUALITY CONTROL**

- A. Tests and Inspections:
  - 1. Test, inspect, and purge natural gas in accordance with the International Fuel Gas Code and authorities having jurisdiction.
  - 2. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- B. Prepare test and inspection reports.

### **3.13 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

### **3.14 OUTDOOR PIPING SCHEDULE**

- A. Underground natural-gas piping is to be one of the following:
  - 1. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
  - 2. Drawn-temper copper tube with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
- B. Aboveground natural-gas piping is to be one of the following:
  - 1. Steel pipe with malleable-iron fittings and threaded joints.
  - 2. Steel pipe with wrought-steel fittings and welded joints.
  - 3. Drawn-temper copper tube with wrought-copper fittings and brazed joints.

**3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 5 PSIG (34.5 kPa)**

- A. Aboveground, branch piping NPS 1 and smaller is to be one of the following:
  - 1. Annealed-temper, copper tube with wrought-copper fittings and brazed joints.
  - 2. Steel pipe with malleable-iron fittings and threaded joints.
- B. Aboveground, distribution piping is to be one of the following:
  - 1. Steel pipe with malleable-iron fittings and threaded joints.
  - 2. Steel pipe with wrought-steel fittings and welded joints.
  - 3. Drawn-temper copper tube with wrought-copper fittings and brazed joints.
- C. Underground, below building, piping is to be one of the following:
  - 1. Steel pipe with malleable-iron fittings and threaded joints.
  - 2. Steel pipe with wrought-steel fittings and welded joints.

**3.16 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 5 PSIG (34.5 kPa)**

- A. Aboveground Piping: Maximum operating pressure more than 5 psig.
- B. Aboveground, Branch Piping: Steel pipe with steel welding fittings and welded joints.
- C. Aboveground, distribution piping is to be one of the following:
  - 1. Steel pipe with steel welding fittings and welded joints.
  - 2. Drawn-temper copper tube with wrought-copper fittings and brazed joints.
- D. Underground, below building, piping is to be one of the following:
  - 1. Steel pipe with malleable-iron fittings and threaded joints.
  - 2. Steel pipe with wrought-steel fittings and welded joints.

**3.17 ABOVEGROUND, MANUAL GAS SHUTOFF VALVE SCHEDULE**

- A. Valves for pipe sizes NPS 2 and smaller at service meter are to be one of the following:
  - 1. One-piece, bronze ball valve with bronze trim.
  - 2. Two-piece, regular-port, bronze ball valves with bronze trim.
  - 3. Bronze plug valve.
- B. Valves for pipe sizes NPS 2-1/2 and larger at service meter are to be one of the following:
  - 1. Two-piece, regular-port, bronze ball valves with bronze trim.
  - 2. Bronze plug valve.

3. Cast-iron, nonlubricated plug valve.

C. Valves in branch piping for single appliance are to be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, regular-port, bronze ball valves with bronze trim.
3. Bronze plug valve.

**END OF SECTION**

## **SECTION 232113 - HYDRONIC PIPING**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

A. Section Includes:

1. Copper tube and fittings.
2. Steel pipe and fittings.
3. Dielectric fittings.

#### **1.2 QUALITY ASSURANCE**

A. Installer Qualifications:

1. Installers of Pressure-Sealed Joints: Installers are to be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

B. Steel Support Welding: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.

C. 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.

#### **1.3 WARRANTY**

A. PP-R and PP-RCT Manufacturer's Warranty: Manufacturer agrees to repair or replace PP-R and PP-RCT pipe and fittings that fail in materials or workmanship within 10 years from date of Substantial Completion.

1. Warranty is to cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or manufacturing.
2. Warranty is to be in effect only upon submission by Contractor to manufacturer of valid pressure/leak documentation indicating that the system was tested and passed manufacturer's pressure/leak test and any other manufacturer requirements.

## **PART 2 - PRODUCTS**

### **2.1 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. Dual-Temperature Heating- and Cooling-Water Piping: 150 psig at 200 deg F.
  - 2. Condenser-Water Piping: 150 psig at 125 deg F.
  - 3. Makeup-Water Piping: 150 psig at 73 deg F.
  - 4. Condensate-Drain Piping: 150 deg F.
  - 5. Pressure-Relief-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

### **2.2 PIPING JOINING MATERIALS**

- A. Solder Filler Metals: ASTM B32, lead-free alloys.
- B. Flux: ASTM B813, water flushable.

## **PART 3 - EXECUTION**

### **3.1 PIPING APPLICATIONS**

- A. See piping schedule on drawings.

### **3.2 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 on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.

- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 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 piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install branch connections to mains using tee 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.
- P. Install air vents and pressure-relief valves in accordance with Section 232116 "Hydronic Piping Specialties."
- Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- S. Install shutoff valve immediately upstream of each dielectric fitting.
- T. Comply with requirements in Section 230500 "Common Work Results for HVAC" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.
- U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.
- V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Common Work Results for HVAC."
- W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230500 "Common Work Results for HVAC."
- X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC."

### **3.3 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 B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
- D. Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," "Pipe and Tube" chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- E. Threaded Joints: Thread pipe with tapered pipe threads in accordance with 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.

### **3.4 INSTALLATION OF DIELECTRIC FITTINGS**

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.
- D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

### **3.5 INSTALLATION OF HANGERS AND SUPPORTS**

- A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- C. Install hangers for copper tubing and steel 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.
- D. 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.



- E. Install hangers for fiberglass 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.
- F. Support horizontal piping within 12 inches of each fitting and coupling.
- G. Support vertical runs of copper tubing and steel piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

### **3.6 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 230500 "Common Work Results for HVAC."

### **3.7 IDENTIFICATION**

- A. Identify system components. Comply with requirements for identification materials and installation in Section 230553 "Identification for HVAC Piping and Equipment."

### **3.8 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.
  - 4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
  - 5. Set temperature controls so all coils are calling for full flow.
  - 6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
  - 7. Verify lubrication of motors and bearings.

### **3.9 FIELD QUALITY CONTROL**

- A. Prepare hydronic piping in accordance with ASME B31.9 and as follows:
  - 1. Leave joints, including welds, uninsulated and exposed for examination during test.

2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; 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**

## **SECTION 232113.13 - UNDERGROUND HYDRONIC PIPING**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

A. Section Includes:

1. Preengineered cased piping system.

#### **1.2 DEFINITIONS**

- A. Invert: Vertical distance from Project datum reference point to bottom interior pipe surface.
- B. Reinforced, Thermosetting Resin Fitting (RTRF): Fittings fabricated of composite materials, largely consisting of a reinforcement material embedded in, or surrounded by, cured thermosetting resin. Most common form of reinforced, thermosetting resin pipe is one in which fiberglass strands form reinforcement.

#### **1.3 ACTION SUBMITTALS**

A. Product Data: For the following:

1. Preengineered conduit piping system components.
2. Preengineered cased piping system components.
3. Cased piping.
4. Loose-fill insulation.

B. Shop Drawings: For underground hydronic piping. Signed and sealed by a professional engineer.

1. Include calculations showing requirements for expansion compensation for underground piping.
2. Show expansion compensators, offsets, and loops with appropriate materials to allow piping movement at required locations. Show anchors and guides that restrain piping movement with calculated loads, and show concrete thrust block dimensions.
3. Show pipe sizes, locations, inverts, and pitch. Show piping in trench, piping in conduit, and cased pipe with details showing clearances between piping.
4. Show insulation thickness.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from hydronic distribution piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.
- B. Source quality-control reports.
- C. Field quality-control reports.

#### **1.5 QUALITY ASSURANCE**

- A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

#### **1.6 FIELD CONDITIONS**

- A. Interruption of Existing Utilities: Do not interrupt utilities serving occupied facilities unless permitted under the following conditions and then only after arranging to provide temporary utility services in accordance with requirements indicated:
  - 1. Notify Owner no fewer than seven days in advance of proposed interruption of utility AND again one day in advance.
  - 2. Do not proceed with interruption of utility without Owner's written permission.

#### **1.7 COORDINATION**

- A. Coordinate pipe-fitting pressure classes with products specified in related Sections.

### **PART 2 - PRODUCTS**

#### **2.1 PERFORMANCE REQUIREMENTS**

- A. Provide components and installation capable of producing hydronic piping systems with the following minimum working-pressure ratings:
  - 1. Condenser-Water Piping: 100 psig at 150 deg F.

#### **2.2 PREENGINEERED CASED PIPING SYSTEM**

- A. Source Limitations: Obtain piping system from single source from single manufacturer.
- B. Description: Factory-fabricated piping with carrier pipe, insulation, and casing.

- C. Carrier Pipe: Materials as indicated in "Piping Application" Article. See articles in this Section for required carrier pipe material characteristics.
- D. Carrier Pipe Insulation:
  - 1. Polyurethane Foam Pipe Insulation: Rigid, cellular, and high-pressure injected between carrier pipe and jacket.
    - a. Comply with ASTM C591; thermal conductivity (k-value) may not exceed 0.165 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.
- E. Casing: HDPE.
- F. Casing accessories include the following:
  - 1. Joint Kit: Half-shell, pourable or split insulation, casing sleeve, and shrink-wrap sleeve.
  - 2. End Seals: Shrink wrap the casing material to seal watertight around casing and carrier pipe.
- G. Source Quality Control: Factory test carrier pipe to 150 percent of operating pressure of system. Furnish test certificates.

## **PART 3 - EXECUTION**

### **3.1 PIPING APPLICATION**

- A. Cooling Tower:
  - 1. NPS 2-1/2 and larger:
    - a. Carrier pipe- type DR-11, high density polyethylene (HDPE), 200 psi, resin type III / grade P34, tensile strength 3300 psi.
    - b. Exterior Casing pipe- type DR-11, High Density Polyethylene (HDPE), 200 psi.
    - c. Interstitial insulation: closed cell polyurethane, fills annular space, 1.5" thick minimum, K-factor- 16 BTUH-sq.ft.-°F/in.
    - d. System shall be designed for 75 psig operating pressure and a temperature range from 0-150°F.
    - e. All field joints shall be per manufacturer's installation instructions for below grade system and shall include: carrier pipe sealing, insulation for connections, and exterior casing sealing.
    - f. Any above ground portions (at cooling tower end) shall be protected from UV exposure.
- B. Dual Temperature Water Piping:
  - 1. NPS 2-1/2 and larger:

- a. Carrier pipe- Schedule 80 ASTM A53 Grade B steel pipe with butt welded fittings.
- b. Exterior Casing pipe- type DR-11, High Density Polyethylene (HDPE), 200 psi.
- c. Interstitial insulation: closed cell polyurethane, fills annular space, 1.5" thick minimum, K-factor- 16 BTUH-sq.ft.-°F/in.
- d. System shall be rated for 150 psig operating pressure and a temperature range from 0-250°F.
- e. All field joints shall be per manufacturer's installation instructions for below grade system and shall include: carrier pipe sealing, insulation for connections, and exterior casing sealing.
- f. All expansion and contraction compensators / fittings / bends, thrust blocks, and associated calculations shall be provided by the manufacturer for the actual system layout for this specific project. Calculations shall be submitted with shop drawings. Expansion / contraction shall be calculated using 40°F during chilled water operation and 200°F for heating water operation.

### **3.2 INSTALLATION OF PIPING**

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Remove standing water in the bottom of trench.
- C. Bed the pipe on a minimum 6-inch layer of pipe system manufacturer's recommended granular fill material with a minimum 6-inch clearance between pipes.
- D. Do not backfill piping trench until field quality-control testing has been completed and results approved.
  1. Provide engineer with 7-day notification to witness the following tests:
    - a. Pressure test of carrier pipe (prior to insulation and sealing outer casing pipe).
    - b. Pipe slope inspection (prior to burial).
- E. Install piping at uniform grade of 0.2 percent. Install required fittings to accommodate capped drains at low points and elsewhere as required for system drainage. Install capped manual air vents at high points. See drawings for detailed information about vents and drains located in outdoor areas.
  1. Maintain continuous bedding under piping. Do not leave gaps in pipe bedding, allowing pipe to sag between contact points with the bedding.
- F. In conduits, install drain valves at low points and manual air vents at high points.
- G. Install components with pressure rating equal to or greater than system operating pressure.
- H. Install piping in straight lines. Do not bend pipe.

- I. Install fittings for changes in direction and branch connections.
- J. See Section 230500 "Common Work Results for HVAC" for sleeves and mechanical sleeve seals through exterior building walls.
- K. Connect to hydronic piping where it passes through the building wall. Hydronic piping inside the building is specified in Section 232113 "Hydronic Piping."
- L. See Section 230523 "General-Duty Valves for HVAC Piping" for sleeves and mechanical sleeve seals through exterior building walls.
- M. After field quality-control testing is complete, backfill with 6 inches of clean, granular material in accordance with piping system manufacturer's written instructions. If mechanical compaction is required, manually backfill to 12 inches before using mechanical-compaction equipment.

### **3.3 JOINT CONSTRUCTION**

- A. Follow manufacturers installation instructions for basic piping joint construction.

### **3.4 IDENTIFICATION**

- A. Install continuous plastic underground warning tapes during backfilling of trenches for underground hydronic piping. Locate tapes 6 to 8 inches below finished grade, directly over piping.

### **3.5 FIELD QUALITY CONTROL**

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
  - 1. Prepare hydronic piping for testing in accordance with ASME B31.9 and as follows:
    - a. Leave joints, including welds, uninsulated and exposed for examination during test.
    - b. Isolate equipment and instrumentation. Do not subject equipment and instrumentation to test pressure.
    - c. Install relief valve set to relieve at pressure no more than one-third higher than test pressure.
    - d. Fill system with water. Where there is risk of freezing, perform testing with air or liquid that will not freeze or cause damage to piping system materials.
    - e. For hydrostatic testing, install vents at high points to release trapped air while filling system. Remove test liquid at accessible low points.
  - 2. Test hydronic piping as follows:

- a. Subject hydronic piping to hydrostatic test pressure that is not less than 1.5 times system design pressure.
  - b. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.
  - c. Do not pressurize carrier pipe with air.
  - d. Maintain test pressure for four hours with no loss of pressure.
3. Test conduit as follows:
  - a. Seal vents and drains and subject conduit to 15-psig compressed air for four hours with no loss of pressure. Repair leaks and retest.
- C. Piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. When successful testing is complete, flush carrier piping to remove dirt or debris remaining after construction. Drain piping after flushing is complete.
- F. Fill underground piping system with permanent system liquid prior to system testing and balancing.

**END OF SECTION 232113.13**



## **SECTION 232116 - HYDRONIC PIPING SPECIALTIES**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

A. Section Includes:

1. Hydronic specialty valves.
2. Air vents.
3. Expansion tanks and fittings.
4. Air/dirt separators and purgers.
5. Strainers.
6. Flexible connectors.

#### **1.2 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.

#### **1.3 CLOSEOUT SUBMITTALS**

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

### **PART 2 - PRODUCTS**

#### **2.1 HYDRONIC SPECIALTY VALVES**

A. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Armstrong Fluid Technology.
  - b. Bell & Gossett; a Xylem brand.
  - c. NIBCO INC.

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Armstrong Fluid Technology.
  - b. Bell & Gossett; a Xylem brand.
  - c. NIBCO INC.
2. Body: Cast-iron or steel body, ball, butterfly, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass- and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig.
11. Maximum Operating Temperature: 250 deg F.

## 2.2 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.

## **2.3 EXPANSION TANKS AND FITTINGS**

### **A. Bladder-Type ASME Expansion Tanks:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. AMTROL, Inc.
  - b. Armstrong Fluid Technology.
  - c. Bell & Gossett; a Xylem brand.
  - d. Taco Comfort Solutions.
2. Tank: Welded steel, rated for 125 psig working pressure and 240 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.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity. Field-replaceable bladder.
4. Sight glass.
5. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

## **2.4 AIR/DIRT SEPARATORS AND PURGERS**

### **A. Tangential-Type Air Separators:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. AMTROL, Inc.
  - b. Armstrong Fluid Technology.
  - c. Bell & Gossett; a Xylem brand.
  - d. Taco Comfort Solutions.
2. Tank: Welded steel; ASME constructed and labeled for 125 psig minimum working pressure and 375 deg F maximum operating temperature.
3. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
4. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
5. Blowdown Connection: Threaded.
6. Size: Match system flow capacity.

## **2.5 STRAINERS**

### **A. Y-Pattern Strainers:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
  - b. Griswold Controls, LLC.
  - c. WATTS; A Watts Water Technologies Company.
  - d. Zurn Industries, LLC.
2. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
3. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
4. CWP Rating: 125 psig.

## **2.6 FLEXIBLE CONNECTORS**

### **A. Spherical, Rubber, Flexible Connectors:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Flexicraft Industries.
  - b. Flo Fab Inc.
  - c. Metraflex Company (The).
2. Body: Fiber-reinforced rubber body.
3. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
4. Performance: Capable of misalignment.
5. CWP Rating: 150 psig.
6. Maximum Operating Temperature: 250 deg F.

## **PART 3 - EXECUTION**

### **3.1 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.

### **3.2 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.

### **3.3 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 in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.
- E. 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.
- F. Install expansion tanks having direct air/water interface above the air separator or air purger. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
  - 1. Install tank fittings that are shipped loose.
  - 2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, and fittings, plus tank full of water. Do not overload building components and structural members.
  - 3. Install piping from air separator or air purger to expansion tank with a 2 percent upward slope toward tank to avoid air entrapment.

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- G. Install diaphragm- or bladder-type expansion tanks on the floor.
- H. Vent and purge air from hydronic system and ensure that tank is properly charged with air to suit system Project requirements.

**END OF SECTION**

## **SECTION 232123 - HYDRONIC PUMPS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

A. Section Includes:

1. Close-coupled, in-line centrifugal pumps.
2. Separately coupled, base-mounted, end-suction centrifugal pumps.

#### **1.2 DEFINITIONS**

- A. ECM: Electronically commutated motor.
- B. EPDM: Ethylene propylene diene monomer.
- C. EPR: Ethylene propylene rubber.
- D. FKM: Fluoroelastomer polymer.
- E. HI: Hydraulic Institute.
- F. NBR: Nitrile rubber or Buna-N.

#### **1.3 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.

#### **1.4 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.
- B. Field quality-control reports.

#### **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

#### **1.6 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Mechanical Seals: One mechanical seal(s) for each pump.

### **PART 2 - PRODUCTS**

#### **2.1 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. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and seismic restraints.
- C. Seismic Performance: Pumps shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.
  - 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.

#### **2.2 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Armstrong Fluid Technology.
  - 2. ITT Corporation.
  - 3. PACO Pumps; Grundfos Pumps Corporation, USA.



- B. Source Limitations: Obtain pumps from single source from single manufacturer.
- C. 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.
- D. Pump Construction:
  - 1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange 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: Type 304 stainless steel.
  - 4. 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.
  - 5. Seal Flushing: Flush, cool, and lubricate pump seal by directing pump discharge water to flow over the seal.
- E. Shaft Coupling: Rigid, axially-split spacer coupling to allow service of pump seal without disturbing pump or motor.
- F. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
  - 1. Enclosure : Totally enclosed, fan cooled.
  - 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
  - 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
  - 5. Inverter duty motor.
  - 6. Provide integral pump motor variable-speed controller or stand-alone variable frequency drive.

## **2.3 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Armstrong Fluid Technology.
  - 2. ITT Corporation.
  - 3. PACO Pumps; Grundfos Pumps Corporation, USA.
- B. Source Limitations: Obtain pumps from single source from single manufacturer.

- C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump with flexible shaft coupling as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.
- D. Pump Construction:
  - 1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections. Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring realignment of pump and motor shaft.
  - 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
  - 3. Pump Shaft: Type 304 stainless steel.
  - 4. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and NBR bellows and gasket.
  - 5. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.
- E. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor.
- F. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.
- G. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A36/A36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.
- H. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
  - 1. Enclosure: Totally enclosed, fan cooled.
  - 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
  - 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
  - 5. Inverter duty motor.
  - 6. Provide integral pump motor variable-speed controller or stand-alone variable speed drive.

## 2.4 PUMP SPECIALTY FITTINGS

- A. Suction Diffuser:
  - 1. Angle pattern.
  - 2. 175-psig pressure rating, ductile-iron body and end cap, pump-inlet fitting.

3. Bronze 16-mesh wire startup and Type 304 stainless steel permanent strainers with 3/16-inch .
4. Type 304 stainless steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Examine foundations and inertia bases for suitable conditions where pumps will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 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. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
  2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
  3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Equipment Mounting for In-Line Pumps Suspended from Structure: Install in-line pumps with continuous-thread hanger rods and spring hangers with vertical-limit stop of size required to support weight of in-line pumps.
  1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

### **3.3 ALIGNMENT**

- A. Engage a factory-authorized service representative to perform alignment service.
- B. Perform alignment service. When required by manufacturer to maintain warranty coverage, engage a factory-authorized service representative to perform it.
- C. Comply with requirements in HI standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.
- D. Comply with pump and coupling manufacturers' written instructions.
- E. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

### **3.4 PIPING CONNECTIONS**

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to pump, allow space for service and maintenance.
- C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- E. Install check and shutoff valves on discharge side of pumps.
- F. Install suction diffuser and shutoff valve on suction side of pumps.
  1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.
- G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- H. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.
- I. Install check valve on each condensate pump unit discharge unless unit has a factory-installed check valve.

### **3.5 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."
  - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

### **3.6 CONTROL CONNECTIONS**

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### **3.7 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.

**3.8 FIELD QUALITY CONTROL**

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Hydronic pumps will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

**3.9 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

**END OF SECTION**

## **SECTION 233113 - METAL DUCTS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Rectangular ducts and fittings - single wall.
  - 2. Round ducts and fittings - single wall.
  - 3. Sheet metal materials.
  - 4. Sealants and gaskets.
  - 5. Hangers and supports.

#### **1.2 DEFINITIONS**

- A. OSHPD: Office of Statewide Health Planning and Development (State of California).

#### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of the following products:
  - 1. Liners and adhesives.
  - 2. Sealants and gaskets.
  - 3. Seismic-restraint devices.
- B. Shop Drawings:
  - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
  - 2. Factory- and shop-fabricated ducts and fittings.
  - 3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
  - 4. Elevation of bottom of ducts.
  - 5. Fittings.
  - 6. Reinforcement and spacing.
  - 7. Seam and joint construction.
  - 8. Penetrations through fire-rated and other partitions.
  - 9. Equipment installation based on equipment being used on Project.
  - 10. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
  - 11. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Field quality control reports.

### **PART 2 - PRODUCTS**

#### **2.1 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. Structural Performance: Duct hangers and supports and seismic restraints are to withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7. Seismically brace duct hangers and supports in accordance with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
- C. Seismic Performance: Ductwork to withstand the effects of earthquake motions. See Section 018123 "Facility Seismic and Wind Criteria" that specifies basis-of-design seismic and wind criteria for nonstructural components. 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.
- D. Airstream Surfaces: Surfaces in contact with airstream comply with requirements in ASHRAE 62.1.
- E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."
- F. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- G. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.



## **2.2 RECTANGULAR DUCTS AND FITTINGS**

### **A. Rectangular Ducts and Fittings - Single Wall:**

1. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on static-pressure class indicated on the Drawings.
  - a. Construct ducts of galvanized sheet steel.
2. 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."
  - a. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
  - b. 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.
3. 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." All longitudinal seams are to be Pittsburgh lock seams unless otherwise specified for specific application.
4. 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."

## **2.3 ROUND DUCTS AND FITTINGS**

### **A. Round Ducts and Fittings - Single Wall:**

1. Source Limitations: Obtain single-wall, round ducts and fittings from single manufacturer.
2. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on static-pressure class indicated on the Drawings.
  - a. Construct ducts of galvanized sheet steel.

## **2.4 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. 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: G90.
  - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
  - 3. Lockforming Quality: Sheet steel and galvanized coating is to be able to be formed with back-to-back bends in seams such as the Pittsburgh lock at high speed without cracking or flaking of the coating on the outside of the bend.

## **2.5 SEALANTS 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. 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.

## **2.6 HANGERS AND SUPPORTS**

- A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.
- B. 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."
- C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.
- D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

- E. Trapeze and Riser Supports:
  - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION OF DUCTS**

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.
- B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- 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.
- 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.
- O. Installation of Metal, Cable-Type Strut Support System for Ductwork: Install in accordance with manufacturer's written installation instructions.

### **3.2 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.

### **3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR TYPE 1 COMMERCIAL KITCHEN GREASE HOOD EXHAUST DUCT**

- A. Install ducts in accordance with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operation"; SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; and SMACNA's "Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines."
- B. Install all ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.
- C. All ducts exposed to view are to be constructed of stainless steel as per "Duct Schedule" Article. All ducts concealed from view are to be carbon steel as per "Duct Schedule" Article.
- D. All joints are to be welded and are to be telescoping, bell, or flange joint as per NFPA 96.

- E. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 12 ft. in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings.
- F. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

### **3.4 ADDITIONAL INSTALLATION REQUIREMENTS FOR EXHAUST DUCTS SERVING COMMERCIAL DISHWASHERS AND OTHER HIGH-HUMIDITY LOCATIONS:**

- A. Install dishwasher exhaust ducts and other exhaust ducts from wet, high-humidity locations without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to dishwasher or toward drain.
- B. Provide a drain pocket at each low point and at the base of each riser with a 1-inch trapped copper drain from each drain pocket to open-sight floor drain.
- C. Minimize number of transverse seams.
- D. Do not locate longitudinal seams on bottom of duct.

### **3.5 REQUIREMENTS FOR 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 G90 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."
- D. Double Wall:
  - 1. Ductwork is to comply with requirements in "Rectangular Ducts and Fittings - Double Wall," "Round Ducts and Fittings - Double Wall," or "Flat-Oval Ducts and Fittings - Double Wall" Product Type.
  - 2. Ductwork outer wall is to be G90 galvanized steel indicated by manufacturer in writing to be suitable for outdoor installation.

3. Provide interstitial insulation as specified under Part 2.
4. If duct outer surface is uninsulated, protect outer surface with suitable paint. Paint materials and application requirements are specified in Section 099113 "Exterior Painting."

### **3.6 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 A.
  4. Outdoor, Return-Air Ducts: Seal Class A.
  5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
  6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher than 2-Inch wg (500 Pa): 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 (500 Pa) and Lower: Seal Class C.
  10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher than 2-Inch wg (500 Pa): Seal Class B.
  11. Conditioned Space, Exhaust Ducts: Seal Class B.
  12. Conditioned Space, Return-Air Ducts: Seal Class C.
  13. Shooting Range, Exhaust Ducts: Seal Class A.

### **3.7 INSTALLATION OF HANGERS AND SUPPORTS**

- 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 ft..
- 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.

### **3.8 INSTALLATION OF SEISMIC-RESTRAINT DEVICES**

- A. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraint installation requirements.

### **3.9 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.

### **3.10 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."

### **3.11 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. Ducts with a Pressure Class Higher than 3-Inch wg (750 Pa): Test representative duct sections, totaling no less than 25 percent of total installed duct area for each designated pressure class.
    - b. Ducts located outdoors: test representative 100 percent of total installed duct area for each designated pressure class.
    - c. Exhaust ducts, filter housing and exhaust equipment used for shooting range: test representative 100 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.
  7. Give seven days' advance notice for testing.
- C. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.
  2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning, and Restoration of HVAC Systems."
    - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media is to not exceed 0.75 mg/100 sq. cm.
- D. Duct system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

### **3.12 DUCT CLEANING**

- A. Clean new duct system(s) before testing, adjusting, and balancing.
- B. For cleaning of existing ductwork, see Section 230130.52 "Existing HVAC Air Distribution System Cleaning."
- C. Use duct cleaning methodology as indicated in NADCA ACR.
- D. Use service openings for entry and inspection.



1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
  2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
  3. Remove and reinstall ceiling to gain access during the cleaning process.
- E. Particulate Collection and Odor Control:
1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
  2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- F. Clean the following components by removing surface contaminants and deposits:
1. Air outlets and inlets (registers, grilles, and diffusers).
  2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
  3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
  4. Coils and related components.
  5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
  6. Supply-air ducts, dampers, actuators, and turning vanes.
  7. Dedicated exhaust and ventilation components and makeup air systems.
- G. Mechanical Cleaning Methodology:
1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
  2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
  3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
  4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
  5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
  6. Provide drainage and cleanup for wash-down procedures.

7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

### **3.13 STARTUP**

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

### **3.14 DUCT SCHEDULE**

- A. Fabricate all ducts with G90 galvanized sheet steel except as otherwise indicated.
- B. See drawings for duct schedule, pressure / seal / and leakage classifications.
- C. Double-Wall Duct Interstitial Insulation:
  1. Supply-Air Ducts: 1-1/2 inches thick.
  2. Exhaust-Air Ducts: 1-1/2 inches thick.
- D. Elbow Configuration:
  1. 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 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
    - b. 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. 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) Radius-to-Diameter Ratio: 1.5.
    - b. Round Elbows:
      - 1) Stamped or pleated for 12 inches and smaller diameters.
      - 2) Standing seam for 14 inches and larger diameter.
- E. 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. All velocities: 45-degree lateral.

**END OF SECTION**

## **SECTION 233300 - AIR DUCT ACCESSORIES**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

**A. Section Includes:**

1. Manual volume dampers.
2. Fire dampers.
3. Turning vanes.
4. Duct-mounted access doors.
5. Flexible connectors.
6. Flexible ducts, insulated.

#### **1.2 ACTION SUBMITTALS**

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

1. Construction details, material descriptions, and dimensions of individual components.
2. For dampers, include housings, linkages, and operators.
3. For damper operators, include electrical or pneumatic pressure rating and damper size rating.
4. For duct-mounted duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.

#### **1.3 CLOSEOUT SUBMITTALS**

**A. Operation and Maintenance Data:** For air duct accessories.

### **PART 2 - PRODUCTS**

#### **2.1 MANUAL VOLUME DAMPERS**

**A. Standard, Steel, Manual Volume Dampers:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Air Balance; MESTEK, Inc.
  - b. Aire Technologies, Inc.; DMI Companies.
  - c. American Warming and Ventilating (AWV); Mestek, Inc.

- d. Arrow United Industries; Mestek, Inc.
- 2. Performance:
  - a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against design differential static pressure.
- 3. Construction:
  - a. Linkage out of airstream.
  - b. Suitable for horizontal or vertical airflow applications.
- 4. 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.
- 5. Blades:
  - a. Multiple or single blade.
  - b. Parallel- or opposed-blade design.
  - c. Stiffen damper blades for stability.
  - d. Galvanized steel; 16 gauge thick.
- 6. Blade Axles: Stainless steel.
- 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.

## 2.2 FIRE DAMPERS

- A. Standards: Comply with NFPA 90A and NFPA 90B.

- B. Type: dynamic; rated and labeled in accordance with UL 555 by an NRTL.
- C. Closing rating in ducts up to 4 inch wg static pressure class and minimum 2000 fpm velocity.
- D. Frame: Curtain type with blades outside 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. 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.

## **2.3 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. Turning Vanes: Fabricate single-wall curved blades of .
- B. 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."
- C. Vane Construction:
  - 1. Wall: Single.

## **2.4 DUCT-MOUNTED ACCESS DOORS AND PRESSURE-RELIEF DOORS**

- A. General Requirements: Fabricate access doors in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2, "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."

## **2.5 DUCT FLEXIBLE CONNECTORS**

- A. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials are to 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 are to 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. Outdoor System, Duct 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.

## **2.6 MATERIALS**

- A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
  - 1. Galvanized Coating Designation: G90.
  - 2. Exposed-Surface Finish: Mill phosphatized.
- B. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.
- C. Tie Rods: Galvanized steel, 3/8-inch minimum diameter.

## **2.7 FLEXIBLE DUCTS, INSULATED**

- A. Standard: Product is to be UL 181 listed and bearing the UL label.
- B. Flexible Ducts, Insulated - Class 0, Interlocking Spiral of Aluminum Foil; Fibrous-Glass Insulation:
  - 1. Pressure Rating: 8 inch wg positive or negative.
  - 2. Maximum Air Velocity: 5000 fpm.
  - 3. Temperature Range: Minus 20 to plus 250 deg F.
  - 4. Insulation R-Value: R8.
  - 5. Vapor-Barrier Film: Aluminized, ASTM E96/E96M.

## **PART 3 - EXECUTION**

### **3.1 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 233533 - LISTED KITCHEN VENTILATION SYSTEM EXHAUST DUCTS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

A. Section Includes:

1. UL-listed, factory-fabricated grease duct - double-wall, 2-hour fire-rated, zero clearance.

#### **1.2 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 UL-listed grease ducts.

B. Shop Drawings: For UL-listed, factory-fabricated grease ducts.

1. Plans, elevations, sections, and 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. Details of fabrication and assembly of hangers and seismic restraints.

#### **1.3 QUALITY ASSURANCE**

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following welding codes:

1. AWS D1.1/D1.1M.
2. AWS D9.1/D9.1M.

### **PART 2 - EXECUTION**

#### **2.1 EXAMINATION**

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

## **2.2 INSTALLATION OF LISTED KITCHEN VENTILATION SYSTEM EXHAUST DUCTS**

- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. Comply with requirements in Section 077200 "Roof Accessories."
- B. Coordinate connections to kitchen exhaust hoods with requirements in Section 233813 "Commercial-Kitchen Hoods."
- C. Coordinate connections to exhaust fans with requirements in Section 233400 "HVAC Fans."
- D. Coordinate firestopping where grease ducts penetrate fire separations with requirements in Section 078413 "Penetration Firestopping."
- E. Comply with all installation requirements of NFPA 96, all applicable codes, and authorities having jurisdiction.
- F. Comply with minimum clearances from combustibles and minimum termination heights in accordance with product listing or NFPA 96 and UL 2221, whichever is most stringent.
- G. Install airtight personnel and maintenance access doors where indicated.
- H. Seal between sections of grease exhaust ducts in accordance with manufacturer's written installation instructions; use sealants recommended in writing by manufacturer.
- I. Grease Duct Supports: Construct duct bracing and supports from noncombustible material.
  - 1. Design bracing and supports to carry static and seismic loads within stress limitations of the International Building Code and NFPA 96.
  - 2. Ensure that bolts, screws, rivets, and other mechanical fasteners do not penetrate duct walls.
- J. Connections: Make grease duct connections in accordance with requirements of applicable codes and authorities having jurisdiction.
  - 1. Grease Duct to Exhaust Fan Connections: Connect grease ducts to inlet side of fan using flanges, gaskets, and bolts.
  - 2. Grease Duct to Hood Connections:
    - a. Make grease duct to hood joints connections using internal or external continuously welded or brazed joints.
    - b. Make watertight grease duct to hood joints connections using flanges, gaskets, and bolts.
- K. Support ducts at intervals recommended by manufacturer to support weight of ducts and accessories, without applying loading on kitchen hoods.
  - 1. Securely attach supports and bracing to structure.

2. Where grease ducts and access doors are large enough for service personnel to enter, provide sufficient structural support to accommodate additional load.
- L. Grease Duct Enclosures: Comply with requirements of all applicable codes and authorities having jurisdiction.
- M. Repair damage to adjacent materials caused by installation of listed kitchen ventilation system exhaust ducts.

### **2.3 FIELD QUALITY CONTROL**

- A. Perform air leakage test in presence of Owner's Representative before concealment of any portion of grease duct system.

**END OF SECTION**

## **SECTION 233713.23 – DIFFUSERS, REGISTERS AND GRILLES**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

A. Section Includes:

1. Diffusers.
2. Grilles.

#### **1.2 ACTION SUBMITTALS**

A. Product Data:

1. For each type of product.
  - a. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
  - b. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

#### **1.3 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Ceiling suspension assembly members.
  2. Method of attaching hangers to building structure.
  3. Size and location of initial access modules for acoustical tile.
  4. Ceiling-mounted items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
  5. Duct access panels.

### **PART 2 - PRODUCTS**

#### **2.1 SCHEDULES**

- A. See drawings for scheduled equipment.

### **PART 3 - EXECUTION**

#### **3.1 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.

#### **3.2 INSTALLATION OF REGISTERS AND GRILLES**

- 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. 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.

#### **3.3 ADJUSTING**

- A. After installation, adjust registers and grilles to air patterns indicated, or as directed, before starting air balancing.

### **END OF SECTION**

## **SECTION 234100 - PARTICULATE AIR FILTRATION**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Pleated panel filters.
  - 2. Supported bag filters.
  - 3. Side-access filter housings.
  - 4. Filter gauges.

#### **1.2 DEFINITIONS**

- A. HIPS: High-impact polystyrene.

#### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
- B. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.
  - 1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
  - 2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

#### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

#### **1.5 QUALITY ASSURANCE**

- A. Testing Agency Qualifications: An NRTL.

## **1.6 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver and store products in a clean, 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.
  - 3. Replace installed products damaged during construction.

## **PART 2 - PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS**

- A. Comply with NFPA 90A and NFPA 90B.
- B. Comply with UL 900.
- 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.

### **2.2 PLEATED PANEL FILTERS**

- A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
- B. Source Limitations: Obtain from single source from single manufacturer.

### **2.3 SUPPORTED BAG FILTERS**

- A. Description: Factory-fabricated, dry, extended surface, self-supported filters with holding frames in steel, basket-type retainer, internal metal grid retainer, or self-supporting media pockets.
- B. Source Limitations: Obtain from single source from single manufacturer.

## **2.4 SIDE-ACCESS FILTER HOUSINGS**

- A. Description: Factory-assembled, side-service housings, constructed of galvanized steel, with flanges to connect to duct or casing system.
- B. Source Limitations: Obtain from single source from single manufacturer.
- C. Prefilters: Integral tracks to accommodate Insert dimension thick, disposable filters.
- D. Access Doors: Hinged, with continuous gaskets on perimeter and positive-locking devices, and arranged so filter cartridges can be loaded from either access door.
- E. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

## **2.5 FILTER GAUGES**

- A. Diaphragm-type gauge with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
- B. Source Limitations: Obtain from single source from single manufacturer.
- C. Diameter: 4-1/2 inches.
- D. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg or Less: 0- to 4.0-inch wg.
- E. Accessories: Static-pressure tips, tubing, gauge connections, and mounting bracket.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION OF FILTERS**

- A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
- B. Install filters in position to prevent passage of unfiltered air.
- C. Install filter gauge for each filter bank.



- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
- E. Coordinate filter installations with duct and air-handling-unit installations.

### **3.3 INSTALLATION OF FILTER GAUGES**

- A. Install filter gauge for each filter bank.
- B. Install filter-gauge, static-pressure taps upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.

### **3.4 CONTROL CONNECTIONS**

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between pressure sensors and DDC system.
- C. Connect control wiring between controlled devices.

### **3.5 FIELD QUALITY CONTROL**

- A. Testing Agency:
  - 1. Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
  - 1. Test for leakage of unfiltered air while system is operating.
- C. Air filter will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

### **3.6 CLEANING**

- A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

### **END OF SECTION**

## **SECTION 235216 - CONDENSING FIRE TUBE BOILERS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

A. Section Includes:

1. Floor-mounted, forced-draft, fire-tube condensing boilers.
2. Condensate-neutralization units.

#### **1.2 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 boilers.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and mounting 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.

#### **1.3 INFORMATIONAL SUBMITTALS**

A. Coordination Drawings: Plans and sections, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for boiler, 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. Source quality-control reports.

- D. Field quality-control reports.

#### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

#### **1.5 WARRANTY**

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period. Where "prorated" is indicated, the boiler manufacturer will cover the indicated percentage of cost of replacement parts. With "prorated" type, covered cost decreases as age of equipment increases.

- 1. Warranty Period:

- a. Heat exchanger / tank damaged by thermal shock or defects in material and workmanship, : 10 years from date of Substantial Completion.
- b. Flue-Gas Condensate Corrosion of Heat Exchanger: Non-Prorated for 10 years from date of Substantial Completion.

### **PART 2 - PRODUCTS**

#### **2.1 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. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
- C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency in accordance with Table 6.8.1-6 and other requirements in Ch. 6 of ASHRAE/IES 90.1.
- D. ASHRAE 90.2 Compliance: Boilers shall have minimum efficiency in accordance with Ch. 6 of ASHRAE 90.2.
- E. DOE Compliance: Minimum efficiency shall comply with 10 CFR 431, Subpart E, Appendix N or 10 CFR 430, Subpart B, Appendix N.
- F. Mounting Base: For securing boiler to concrete base.
  - 1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

## **2.2 FLOOR-MOUNTED, FORCED-DRAFT, FIRE-TUBE CONDENSING BOILERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. AERCO; A WATTS Brand.
  - 2. Fulton Boiler Works, Inc.
  - 3. Lochinvar, LLC.
- B. Description: Factory-fabricated, -assembled, and -tested, fire-tube, forced-draft, condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Units are to be for water-heating service only.
- C. Primary Heat Exchanger: Corrosion-resistant Type 316 stainless steel.
- D. Secondary Heat Exchanger: Corrosion-resistant Type 316 stainless steel.
- E. Combustion Chamber and Flue Pipes: Corrosion-resistant stainless steel.
- F. Pressure Vessel: Carbon steel with welded heads and tube connections.
- G. Burner: Natural gas, forced draft.
- H. Blower: Centrifugal fan to operate during each burner-firing sequence and to prepurge and postpurge the combustion chamber.
  - 1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
    - a. Motor Sizes: Large enough so driven load will not require motor to operate in service factor range above 1.0.
- I. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
- J. Ignition: Direct-spark ignition or silicone carbide hot-surface ignition with 100 percent main-valve shutoff and electronic flame supervision.
- K. Casing:
  - 1. Jacket: Sheet metal, with snap-in or interlocking closures.
  - 2. Control Compartment Enclosures: NEMA 250, Type 1A.
  - 3. Finish: Baked-enamel protective finish.
  - 4. Insulation: Minimum 2-inch- thick, mineral-fiber insulation surrounding the heat exchanger.
  - 5. Combustion-Air Connections: Inlet and vent duct collars.

## **2.3 TRIM - FOR HOT-WATER BOILERS**

- A. Include devices sized to comply with ASME B31.9.
- B. Safety Relief Valve: ASME rated.
- C. Pressure and Temperature Gauge: Minimum 3-1/2-inch- diameter, combination water-pressure and -temperature gauge. Gauges shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.
- D. High and low gas-pressure switches.
- E. Alarm bell with silence switch.
- F. Drain Valve: Minimum NPS 3/4 hose-end gate valve.

## **2.4 CONTROLS**

- A. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
  - 1. Hardwired Points:
    - a. Monitoring: On/off status, common trouble alarm low-water-level alarm.
    - b. Control: On/off operation, hot-water-supply temperature set-point adjustment.

## **2.5 ELECTRICAL POWER**

- A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
  - 1. House in NEMA 250, Type 1 enclosure.
  - 2. Wiring shall be numbered and color coded to match wiring diagram.
  - 3. Install factory wiring outside of an enclosure in a metal raceway.
  - 4. Field power interface shall be to fused disconnect switch.
  - 5. Provide branch power circuit to each motor and to controls with a disconnect switch.
  - 6. Provide each motor with overcurrent protection.

## **2.6 VENTING KITS**

- A. Kit: Complete system, ASTM A959, Type 29-4C stainless steel pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.
- B. Combustion-Air Intake: Complete system, stainless steel pipe, vent terminal with screen, inlet air coupling, and sealant.

## **2.7 CONDENSATE-NEUTRALIZATION UNITS**

- A. Description: Factory-fabricated and -assembled condensate-neutralizing tank assembly of corrosion-resistant plastic material with threaded or flanged inlet and outlet pipe connections. Device functions to prevent acidic condensate from damaging grain system. It is to be piped to receive acidic condensate discharged from condensing boiler and neutralize it by chemical reaction with replaceable neutralizing agent. Neutralized condensate is then piped to suitable drain.
- B. features:
  - 1. All corrosion-resistant material.
  - 2. Suitable for use on all natural gas and propane boilers.
  - 3. Includes initial charge of neutralizing agent.
  - 4. Neutralizing agent to be easily replaceable when exhausted.
  - 5. Inlet and outlet pipe connections.
- C. Tank Configuration:
  - 1. Utilized where boiler is elevated or where tank is installed in a pit with tank top flush with floor.
  - 2. Top easily removed for neutralizing agent replacement.
  - 3. Internal baffles to channel flow for complete neutralization.
  - 4. Integral bypass to prevent condensate backflow into appliance.
  - 5. Multiple units may be used for larger capacity.

## **2.8 SOURCE QUALITY CONTROL**

- A. UL Compliance: Test gas-fired boilers having input of more than 400,000 Btu/h for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.
- B. UL Compliance, Oil-Fired: Test oil-fired boilers for compliance with UL 726. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.
- C. UL Compliance, Gas-Fired: Test gas-fired boilers for compliance with UL 2764. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.
- D. CSA Compliance: Test boilers for compliance with ANSI Z21.13-2017/CSA 4.9.
- E. Performance Testing: Test and label boilers for efficiency to comply with AHRI 1500.
- F. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

- G. Test and inspect factory-assembled boilers, before shipping, in accordance with 2017 ASME Boiler and Pressure Vessel Code. Factory test boilers for safety and functionality; fill boiler with water, and fire throughout firing range, to prove operation of all safety components.
- H. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.
  - 1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- B. Examine mechanical spaces for suitable conditions where boilers will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 BOILER INSTALLATION**

- A. Equipment Mounting:
  - 1. Install floor-mounted boilers 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. Install wall-hung boilers where indicated on Drawings using suitable hangers. Comply with manufacturer's mounting instructions.
  - 3. Comply with requirements for vibration isolation and seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
  - 4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Install gas-fired boilers according to NFPA 54.
- C. Assemble and install boiler trim.
- D. Install electrical devices furnished with boiler but not specified to be factory mounted.
- E. Install control wiring to field-mounted electrical devices.

### **3.3 PIPING CONNECTIONS**

- A. Comply with requirements for hydronic piping specified in Section 232113 "Hydronic Piping."
- B. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232116 "Hydronic Piping Specialties."
- C. Drawings indicate general arrangement of piping, fittings, and specialties.
- D. When installing piping adjacent to boiler, allow space for service and maintenance of condensing boilers. Arrange piping for easy removal of condensing boilers.
- E. Install condensate drain piping to condensate-neutralization unit and from neutralization unit to nearest floor drain. Piping shall be at least full size of connection. Install piping with a minimum of 2 percent downward slope in direction of flow.
- F. Install condensate piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Install piping with a minimum of 2 percent downward slope in direction of flow.
- G. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.
- H. Connect hot-water piping to supply- and return-boiler tapings with shutoff valve, and union or flange at each connection.
- I. Install piping from safety relief valves to nearest floor drain.

### **3.4 DUCT CONNECTIONS**

- A. Boiler Venting:
  - 1. Install flue-venting kit and combustion-air intake.
  - 2. Utilize vent and intake duct material, size, and configuration as indicated in boiler manufacturer's instructions and to comply with UL 1738.
  - 3. Connect boiler vent full size to boiler connections.
  - 4. Comply with requirements in Section 235123 "Gas Vents."
  - 5. Comply with all boiler manufacturer's installation instructions.

### **3.5 ELECTRICAL CONNECTIONS**

- A. Connect wiring in accordance with 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.

### **3.6 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.
  - 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.

### **3.7 FIELD QUALITY CONTROL**

- A. Testing Agency, Contractor: Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
  - 1. Perform installation and startup checks in accordance with manufacturer's written instructions.
  - 2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
  - 3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    - a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
    - b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Boiler will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

- E. Occupancy Adjustments: When requested within 4 full seasons 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.

### **3.8 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training."
  - 1. Instructor shall be factory trained and certified.
  - 2. Provide not less than two hours of training.
  - 3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
  - 4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
  - 5. Obtain Owner sign-off that training is complete.
  - 6. Owner training shall be held at Project site.

### **END OF SECTION**

## **SECTION 236426.16 - WATER-COOLED, ROTARY-SCREW WATER CHILLERS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

A. Section Includes:

1. Packaged, water-cooled, single-compressor chillers.

#### **1.2 DEFINITIONS**

- A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
- B. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
- C. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated in accordance with the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.
- D. kVAr: Kilovolt amperes reactive.
- E. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
- F. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated in accordance with the method defined by AHRI 550/590 and intended for operating conditions other than AHRI standard rating conditions.
- G. RTD: Resistance temperature detector.

#### **1.3 ACTION SUBMITTALS**

A. Product Data: For each type of product.

1. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
  - a. Performance at AHRI standard conditions and at conditions indicated.
  - b. Performance at AHRI standard unloading conditions.
  - c. Minimum evaporator flow rate.
  - d. Refrigerant capacity of chiller.
  - e. Oil capacity of chiller.

- f. Fluid capacity of evaporator.
- g. Characteristics of safety relief valves.
- h. Fluid capacity of condenser.
- i. Minimum entering condenser-fluid temperature.
- j. Performance at varying capacities with constant-design, entering condenser-fluid temperature. Repeat performance at varying capacities for different condenser-fluid temperatures from design to minimum in 5 deg F increments.

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.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Certificates: For certification required in "Quality Assurance" Article.
- C. Seismic Qualification Data: Certificates, for chillers, accessories, and components, from manufacturer. Submit certification that specifies equipment will withstand wind forces identified in Section 018123 "Facility Seismic and Wind Criteria" and coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."
  - 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.
- D. Source quality-control reports.
- E. Field Quality-Control Reports: Startup service reports.
- F. Sample Warranty: For special warranty.

#### **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals.

## **1.6 QUALITY ASSURANCE**

- A. AHRI Certification: Certify chiller in accordance with AHRI 550 certification program.

## **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Ship chillers from the factory fully charged with refrigerant.
- B. Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.
- C. Ship each oil-lubricated chiller with a full charge of oil.
  - 1. Ship oil factory installed in chiller.

## **1.8 WARRANTY**

- A. Special Warranty: Manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
  - 1. Extended warranties include, but are not limited to, the following:
    - a. Complete chiller including refrigerant and oil charge.
    - b. Complete compressor and drive assembly including refrigerant and oil charge.
    - c. Refrigerant and oil charge.
    - d. Parts only and labor.
    - e. Loss of refrigerant charge for any reason.
  - 2. Warranty Period: Five years from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS**

- A. Seismic Performance: Rotary-screw chillers are to withstand the effects of earthquake motions. See Section 230548 "Vibration and Seismic Controls for HVAC" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria.
  - 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. Component Importance Factor: 1.5.
- B. Condenser-Fluid Temperature Performance:

1. Startup Condenser-Fluid Temperature: Chiller is to be capable of starting with an entering condenser-fluid temperature of 55 deg F and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
  2. Minimum Operating Condenser-Fluid Temperature: Chiller is to be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 55 deg F.
  3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
- C. Site Altitude: Chiller is to be suitable for altitude in which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
- D. AHRI Rating: Rate chiller performance in accordance with requirements in AHRI 550/590.
- E. ASHRAE Compliance:
1. ASHRAE 15 for safety code for mechanical refrigeration.
  2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.
- F. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- G. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and include an ASME U-stamp and nameplate certifying compliance.
- H. Comply with NFPA 70.
- I. Comply with requirements of UL and UL Canada and include label by a qualified testing agency showing compliance.

## **2.2 PACKAGED, WATER-COOLED, SINGLE-COMPRESSOR CHILLERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carrier Global Corporation.
  2. Dunham-Bush, Inc.
  3. Trane.
  4. York International Corporation.
- B. Chiller must arrive and be installed as one complete assembly (disassembled units are not allowed). Contractor shall verify all dimensions (especially in the pit area) during the bidding process to confirm that the selected equipment can be installed as a single unit. Only one of the walls in the pit is allowed to be removed (as shown on project drawings). Failure to meet this requirement shall result in Contractor providing the correct equipment without any further costs to the Owner or Engineer.

- C. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.
- D. Compressor:
  - 1. Description: Semi-hermetic, rotary compressor, capacity control slide valve and differential pressure oil lubrication system.
  - 2. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
  - 3. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
  - 4. Seals: Hermetically sealed.
- E. Compressor Motor:
  - 1. Continuous-duty, direct drive, squirrel-cage, induction-type motor with energy efficiency required to suit chiller energy efficiency indicated.
  - 2. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
  - 3. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
- F. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.
  - 1. Overspeed Test: 25 percent above design operating speed.
- G. Service: Easily accessible for inspection and service.
  - 1. Compressor's internal components are to be accessible without having to remove compressor-drive assembly from chiller.
  - 2. Provide lifting lugs or eyebolts attached to casing.
- H. Capacity Control: Modulating slide-valve assembly or port unloaders combined with a variable-frequency controller, if applicable, to achieve performance indicated.
  - 1. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
  - 2. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design, entering condenser-fluid temperature.
- I. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.
  - 1. Oil filter to be the easily replaceable cartridge type, minimum 0.5-micron efficiency, with means of positive isolation while servicing.
  - 2. Refrigerant- or water-cooled oil cooler.
  - 3. Factory-installed and pressure-tested piping with isolation valves and accessories.
  - 4. Oil compatible with refrigerant and chiller components.
  - 5. Positive visual indication of oil level.

J. Refrigeration Systems:

1. Refrigerant Type: R-513A.
2. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.
3. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell.

K. Evaporator:

1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.
2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
3. Designed to prevent liquid refrigerant carryover from entering compressor.
4. Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.
5. Tubes:
  - a. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
  - b. Material: Copper or copper-nickel alloy.
  - c. Minimum Wall Thickness: Manufacturer's standard.
  - d. External Finish: Manufacturer's standard.
  - e. Internal Finish: Enhanced.
6. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

L. Condenser:

1. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
2. Provide condenser with sight glass or other form of positive visual verification of refrigerant charge and condition.
3. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

M. Electrical Power:

1. Factory installed and wired, and functionally tested at factory before shipment.
2. Single-point, field-power connection to circuit breaker. Minimum withstand rating is to be as required by electrical power distribution system, but not less than 65,000A.
  - a. Provide branch power circuit to each motor, electric heater, dedicated electrical load, and controls circuit breaker.



- b. Control-circuit transformer with primary and secondary side fuses.
- 3. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

N. Motor Controller:

- 1. Enclosure: Factory installed, unit mounted, NEMA 250, Type 4, with hinged full-front access door with lock and key or padlock and key.
- 2. Control Circuit: Obtained from integral control power transformer with a control power transformer of enough capacity to operate connected control devices.
- 3. Overload relay is to be sized in accordance with UL 1995 or be an integral component of chiller control microprocessor.
- 4. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.
- 5. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.
- 6. Accessories: Devices are to be factory installed in controller enclosure unless otherwise indicated.
  - a. Externally Operated, Door-Interlocked Disconnect: Circuit breaker. Minimum withstand rating is to be as required by electrical power distribution system, but not less than 65,000A.
  - b. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
  - c. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
  - d. Control Relays: Time-delay relays.
  - e. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.

O. Variable-Frequency Controller:

- 1. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
- 2. Technology: Pulse-width-modulated output suitable for constant or variable torque loads.
- 3. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
- 4. Operating Requirements:
  - a. Input AC Voltage Tolerance: 460-V ac, plus 10 percent or 506 V maximum.
  - b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
  - c. Capable of driving full load, without derating, under the following conditions:
    - 1) Ambient Temperature: 0 to 40 deg C.
    - 2) Relative Humidity: Up to 95 percent (noncondensing).
    - 3) Altitude: 750 feet.
  - d. Minimum Efficiency: 96 percent at 60 Hz, full load.

- e. Minimum Displacement Primary-Side Power Factor: 98 percent.
  - f. Overload Capability: 1.05 times the full-load current for seven seconds.
  - g. Starting Torque: As required by compressor-drive assembly.
  - h. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller is not to operate continuously.
  - i. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
5. Internal Adjustability Capabilities:
- a. Minimum Output Frequency: 6 Hz.
  - b. Maximum Output Frequency: 60 Hz.
  - c. Acceleration: 2 to 60 seconds.
  - d. Deceleration: Zero to 60 seconds.
  - e. Current Limit: 30 to a minimum of 100 percent of maximum rating.
6. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions is to not result in component failure or the need for replacement:
- a. Overtemperature.
  - b. Short circuit at controller output.
  - c. Ground fault at controller output. Variable-frequency controller is to be able to start a grounded motor.
  - d. Open circuit at controller output.
  - e. Input undervoltage.
  - f. Input overvoltage.
  - g. Loss of input-phase.
  - h. Reverse phase.
  - i. AC line switching transients.
  - j. Instantaneous overload, line to line or line to ground.
  - k. Sustained overload exceeding 100 percent of controller rated current.
  - l. Starting a rotating motor.
7. Motor Protection: Controller is to protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
8. Automatic Reset and Restart: Capable of three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller is to be capable of automatic restart on phase-loss, and overvoltage and undervoltage trips.
9. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:
- a. Power on.
  - b. Run.
  - c. Overvoltage.
  - d. Line fault.
  - e. Motor speed (percent).
  - f. Fault or alarm status (code).

- g. Motor output voltage.
  - h. Input kilovolt amperes.
  - i. Total power factor.
  - j. Input kilowatts.
  - k. Input kilowatt-hours.
  - l. Three-phase input voltage.
  - m. Three-phase output voltage.
  - n. Three-phase input current.
  - o. Three-phase output current.
  - p. Output frequency (Hertz).
  - q. Elapsed operating time (hours).
  - r. Diagnostic and service parameters.
10. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.
11. Harmonic Distortion Filter: Factory mounted and wired to limit total voltage and current distortion to 5 percent.

P. Controls:

- 1. Standalone and microprocessor based with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
- 2. Enclosure: Unit mounted, NEMA 250, Type 4, hinged or lockable; factory wired with a single-point, field-power connection and a separate control circuit.
- 3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:
  - a. Date and time.
  - b. Operating or alarm status.
  - c. Fault history with not less than last 10 faults displayed.
  - d. Set points of controllable parameters.
  - e. Trend data.
  - f. Operating hours.
  - g. Number of chiller starts.
  - h. Outdoor-air temperature or space temperature if required for chilled-water reset.
  - i. Temperature and pressure of operating set points.
  - j. Entering- and leaving-fluid temperatures of evaporator and condenser.
  - k. Difference in fluid temperatures of evaporator and condenser.
  - l. Fluid flow of evaporator and condenser.
  - m. Fluid pressure drop of evaporator and condenser.
  - n. Refrigerant pressures in evaporator and condenser.
  - o. Refrigerant saturation temperature in evaporator and condenser.
  - p. Pump status.
  - q. Antirecycling timer status.
  - r. Percent of maximum motor amperage.
  - s. Current-limit set point.
  - t. Compressor bearing temperature.
  - u. Motor bearing temperature.

- v. Motor winding temperature.
  - w. Oil temperature.
  - x. Oil discharge pressure.
  - y. Phase current.
  - z. Percent of motor rated load amperes.
  - aa. Phase voltage.
  - bb. Demand power (kilowatts).
  - cc. Energy use (kilowatt-hours).
  - dd. Power factor.
4. Control Functions:
- a. Manual or automatic startup and shutdown time schedule.
  - b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator fluid temperature is to be reset based on outside air temperature.
  - c. Current limit and demand limit.
  - d. Condenser-fluid temperature.
  - e. External chiller emergency stop.
  - f. Antirecycling timer.
  - g. Variable evaporator flow.
5. Manually Reset Safety Controls: The following conditions are to shut down chiller and require manual reset:
- a. Low evaporator pressure or temperature; high condenser pressure.
  - b. Low evaporator fluid temperature.
  - c. Low oil differential pressure.
  - d. High or low oil pressure.
  - e. High compressor-discharge temperature.
  - f. Loss of condenser-fluid flow.
  - g. Loss of evaporator-fluid flow.
  - h. Motor overcurrent.
  - i. Motor overvoltage.
  - j. Motor undervoltage.
  - k. Motor phase reversal.
  - l. Motor phase failure.
  - m. Sensor- or detection-circuit fault.
  - n. Processor communication loss.
  - o. Motor controller fault.
  - p. Extended compressor surge.
6. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
7. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
8. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.

9. Communication Port: RS-232 port or equivalent connection capable of connecting a printer and a notebook computer.
10. Interface with the DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display chiller status and alarms.
  - a. ASHRAE 135 (BACnet) communication interface with the DDC system for HVAC is to enable the DDC system for HVAC operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel are to be available through the DDC system for HVAC.

Q. Insulation:

1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C534, Type I for tubular materials and Type II for sheet materials.
2. Thickness: 3/4 inch.
3. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
4. Factory-applied insulation over cold surfaces of chiller capable of forming condensation. Components are to include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
  - a. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
  - b. Seal seams and joints to provide a vapor barrier.
  - c. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.

R. Finish:

1. Provide Owner with quart container of paint used in application of topcoat to use in touchup applications after Project closeout.

S. Accessories:

1. Flow Switches:
  - a. If required and not factory installed, chiller manufacturer is to furnish a switch for each evaporator and condenser and verify field-mounting location before installation.
  - b. Paddle Flow Switches:
    - 1) Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.
    - 2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.

- 3) Pressure rating equal to pressure rating of heat exchanger.
- 4) Construct body and wetted parts of Type 316 stainless steel.
- 5) House switch in a NEMA 250, Type 4 enclosure constructed of die-cast aluminum.

c. Pressure Differential Switches:

- 1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
- 2) Performance: Switch is to withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
- 3) Set Point: Screw type, field adjustable.
- 4) Electrical Connections: Internally mounted screw-type terminal blocks.
- 5) Switch Enclosure: NEMA 250, Type 4.
- 6) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.

2. Vibration Isolation:

a. Chiller manufacturer is to furnish vibration isolation for each chiller.

b. Neoprene Pad:

- 1) Two layers of 0.375-inch- thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless steel plate.
- 2) Fabricate pads from 40- to 50-durometer neoprene.
- 3) Provide stainless steel square bearing plate to load the pad uniformly between 20 and 40 psig with a 0.12- to 0.16-inch deflection.

c. Spring Isolator:

- 1) Stable in operation and designed for not less than 30 percent reserve deflection beyond actual operating conditions. Isolators are to be designed such that the  $K_x/K_y$  ratio is to be 1.0 or more for stability.
- 2) Provide PVC or neoprene-coated springs and hot-dip, galvanized-steel components. Aluminum components are to be etched and painted. Nuts, bolts, and washers are to be zinc electroplated.
- 3) Isolators are to be adjustable and with an open spring, having one or more coil springs attached to a top compression plate and a baseplate. An elastomeric pad with a minimum thickness of 0.25 inch is to be bonded to the baseplate.
- 4) Spring assembly is to be removable and fit within a welded steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation. Isolated restraining bolts are to not be engaged during normal operation and connect the top plate and lower housing to prevent the isolated equipment from rising when drained of fluid.
- 5) Isolators are to be selected for a nominal 2-inch deflection.

3. Tool Kit: Chiller manufacturer is to assemble a tool kit specially designed for use in serving the chiller(s) furnished. Include special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance. Place tools in a lockable case with hinged cover. Provide a list of each tool furnished and attach the list to underside of case cover.

T. Capacities and Characteristics- see schedules on drawings.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine chillers before installation. Reject chillers that are damaged.
- B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.
  1. Final chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION OF WATER-COOLED, ROTARY-SCREW WATER CHILLERS**

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
- B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.
- C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.
- D. Install chillers on support structure indicated.
- E. Equipment Mounting:
  1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
  2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
  3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- F. Maintain manufacturer's recommended clearances for service and maintenance.
- G. Charge chiller with refrigerant and fill with oil if not factory installed.

- H. Install separate devices furnished by manufacturer and not factory installed.

### **3.3 INSTALLATION OF HEAT-EXCHANGER, BRUSH-CLEANING SYSTEM**

- A. Install brush-cleaning system control panel adjacent to chiller control panel.
- B. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
- C. Provide field electric power, as required, to each system control panel and electric actuated valve.
- D. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.
- E. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
- F. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.

### **3.4 STARTUP SERVICE**

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Verify that pumps are installed and functional.
  - 2. Check bearing lubrication and oil levels.
  - 3. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
  - 4. Verify proper motor rotation.
  - 5. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
  - 6. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
  - 7. Verify and record performance of chiller protection devices.
  - 8. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
- B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
- C. Prepare test and inspection startup reports.



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### **3.5 DEMONSTRATION**

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chillers.

**END OF SECTION**

## **SECTION 237433 - DEDICATED OUTDOOR-AIR UNITS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

A. Section Includes:

1. Dedicated outdoor-air units.

#### **1.2 DEFINITIONS:**

- A. ECM: Electronically commutated motor.
- B. IS COP: Integrated Seasonal Coefficient of Performance.
- C. ISMRE: Integrated Seasonal Moisture Removal Efficiency.
- D. MRC: Moisture Removal Capacity.

#### **1.3 ACTION SUBMITTALS**

A. Product Data:

1. For each type of product.
  - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  - b. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
  - c. Include unit dimensions and weight.
  - d. Include cabinet material, metal thickness, finishes, insulation, and accessories.
  - e. 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, electrical characteristics, and motor accessories.
  - f. Include certified coil-performance ratings with system operating conditions indicated.
  - g. Include filters with performance characteristics.
  - h. Include heat exchangers with performance characteristics.
  - i. Include dampers, including housings, linkages, and operators.

- B. Shop Drawings: For each dedicated outdoor-air unit.
  - 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.
- C. Delegated Design Submittal: For dedicated outdoor-air-unit supports indicated to comply with performance and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - 1. Include design calculations for selecting vibration isolators, seismic restraints, and wind restraints, and for designing vibration isolation bases.
  - 2. Wind- and Seismic-Restraint Details: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
  - 3. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Floor/roof plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force 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. Source quality-control reports.
- D. Startup service reports.
- E. Field quality-control reports.

#### **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For dedicated outdoor-air units to include in emergency, operation, and maintenance manuals.

## **1.6 WARRANTY**

- A. Warranty: Manufacturer agrees to replace components of dedicated outdoor-air units that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period for Dedicated Outdoor-Air-Handling Units: Two years from date of Substantial Completion.
  - 2. Warranty Period for Compressors: Five years from date of Substantial Completion.
  - 3. Warranty Period for Heat Exchangers: Five years from date of Substantial Completion.
  - 4. Warranty Period for Air to Air Heat Exchangers: Five years from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an "NRTL" (nationally recognized testing laboratory), and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units 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 and ASHRAE 34 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. ASHRAE 84 Compliance: Comply with capacity ratings for fixed plate energy-recovery equipment.
- G. UL Compliance:
  - 1. Electric Coils: Comply with requirements in UL 1995.
- H. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, seismic restraints, and wind restraints.
- I. Seismic Performance: Units are to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7. 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 when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

J. Wind-Restraint Performance:

1. See Section 230548 "Vibration and Seismic Controls for HVAC."

## 2.2 DEDICATED OUTDOOR-AIR UNITS

A. Source Limitations: Obtain dedicated outdoor-air units from single manufacturer.

B. Unit Casing:

1. 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.
2. Configuration: Horizontal unit with horizontal discharge for roof-mounting installation.

C. Fans, Drives, And Motors:

1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
2. Supply-Air Fans and Relief-Air Fans: Centrifugal; galvanized or painted steel; mounted on solid-steel shaft.
  - a. Shafts: With field-adjustable alignment.
    - 1) Turned, ground, and polished hot-rolled steel with keyway.
  - b. Shaft Bearings:
    - 1) Heavy-duty, self-aligning, pillow-block type with an L-50 rated life of minimum 100,000 hours in accordance with ABMA 9.
  - c. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
  - d. 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.
    - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives are to comply with UL 181, Class 1.
3. Drive, Direct: Factory-mounted direct drive.

4. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated multispeed motors.
  5. Motors:
    - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
    - b. Enclosure Type: Open, drip proof.
    - c. Enclosure Materials: Cast iron.
    - d. Efficiency: Inverter duty.
    - e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
    - f. Mount unit-mounted disconnect switches on exterior of unit.
- D. Coils:
1. General Requirements for Coils:
    - a. Comply with AHRI 410.
    - b. Fabricate coils section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
    - c. Coils are not to act as structural component of unit.
  2. Supply-Air Refrigerant Coils:
    - a. Tubes: Copper.
    - b. Fins: Aluminum.
    - c. Fin and Tube Joints: Mechanical bond.
    - d. Headers: Seamless-copper headers with brazed connections.
    - e. Frames: Galvanized steel.
    - f. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
      - 1) Working Pressure: Minimum 300 psig.
- E. Refrigeration Circuit Components:
1. Compressors: Hermetic, variable-speed scroll compressors, mounted on integral vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.
  2. Refrigerant: R-410A or R-454B.
- F. Air Filtration:
1. Panel Filters:
    - a. Description: Pleated factory-fabricated, self-supported disposable air filters with holding frames.
    - b. Filter Unit Class: UL 900.

- c. Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
- d. Filter-Media Frame: see filter specifications.

G. Indirect-Fired Gas Furnace Heating:

- 1. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47 and with NFPA 54.
- 2. CSA Approval: Designed and certified by and bearing label of CSA.
- 3. Burners:
  - a. Heat-Exchanger Material: Stainless steel.
  - b. Fuel: Natural gas.
  - c. Ignition: Electronically controlled electric spark with flame sensor.
  - d. Gas Control Valve: Electronic modulating.
  - e. Gas Train: Single-body, regulated, redundant, 24 V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

H. Electrical Power Connections:

- 1. Single-Point Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other necessary electrical devices are to provide a single-point field power connection to unit .
- 2. Enclosure: NEMA 250, Type 4, mounted in unit with hinged access door in unit cabinet having a lock and key or padlock and key.
- 3. Wiring: Numbered and color-coded to match wiring diagram.
- 4. Wiring Location: Install factory wiring outside an enclosure in a raceway.
- 5. Power Interface: Field power interface to be NEMA KS 1, heavy-duty, nonfused disconnect switch.
- 6. Factory Wiring: Branch power circuit to each motor and to controls with one of the following disconnecting means:
  - a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection in accordance with IEC 60947-4-1.
  - b. NEMA KS 1, heavy-duty, nonfusible switch.
  - c. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
- 7. Factory-Mounted, Overcurrent-Protection Service: For each motor.
- 8. Controls: Factory wire unit-mounted controls where indicated.
  - a. Service Lights: vaporproof luminaire with individual switched junction box located adjacent to each access door and panel.
    - 1) Locations: Each section accessed with door or panel.

- b. Convenience Outlets: One 20 A duplex GFCI receptacle per location with junction box located on outside casing wall.
        - 1) Locations: Fan section.
- 9. Control Relays: Auxiliary and adjustable time-delay relays.
- I. Controls:
  - 1. See controls sequences and points list on drawings.
- J. Roof Curbs:
  - 1. Curb Dimensions: Height of 14 inches.
  - 2. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for wind-load requirements.
- K. Intake And Relief Openings:
  - 1. Materials: Match material and finish of casing exterior.
  - 2. Bird Screen: Comply with requirements in ASHRAE 62.1.

## **2.3 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.
- E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.
- F. Corrosion-Resistant Coating: Coat casing, coils, and fan guards with a corrosion-resistant coating capable of withstanding a 3,000-hour salt-spray test in accordance with ASTM B117.
  - 1. Standards:
    - a. ASTM B117 for salt spray.



- b. ASTM D2794 for minimum impact resistance of 100 in-lb.
  - c. ASTM D3359 for cross-hatch adhesion of 5B.
- 2. Application: Spray.
- 3. Thickness: 1 mil.
- 4. Gloss: Minimum gloss of 50 gloss units on a single angle 60-degree meter.

## **2.4 SOURCE QUALITY CONTROL**

- A. AHRI 920: Manufacturer to certify that performance ratings are in accordance with AHRI 920 if AHRI 920 certification program is not in place. Provide AHRI 920 certification if AHRI 920 certification program is in place.
- B. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label unit fan sound ratings in accordance with AHRI 260 or AMCA 311.
- C. Fan Aerodynamic Performance Rating: Test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency.
  - 1. Test and rate fan performance in accordance with AMCA 210.
- D. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.
- E. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.
- F. Damper Leakage and Air Performance:
  - 1. Damper Rating: Test and rate dampers for leakage and air performance in accordance with AMCA 510.
- G. Water Coils: Factory tested to 300 psig in accordance with AHRI 410 and ASHRAE 33.
- H. Refrigerant Coils: Factory tested to minimum 300 psig internal pressure and to minimum 300 psig internal pressure while under water, in accordance with AHRI 410 and ASHRAE 33.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

- C. Examine roof curbs and equipment supports for suitable conditions where units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION OF DEDICATED OUTDOOR-AIR UNITS**

- A. Unit Support: Install unit level on structural curbs. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of curbs with actual equipment provided.
  - 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 for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
- C. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.
- D. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
- E. Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.
- F. Comply with requirements for gas-fired furnace installation in NFPA 54.
- G. Install separate devices furnished by manufacturer and not factory installed.
- H. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

### **3.3 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 units, allow space for service and maintenance.
- C. Connect piping to units mounted on vibration isolators with flexible connectors.
- D. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

- E. Gas Piping: Comply with requirements in Section 231123 "Facility Natural-Gas Piping." Provide AGA-approved flexible connectors.
  - 1. Connect gas piping to furnace, full size of gas train inlet, and connect with union, pressure regulator, and shutoff valve with sufficient clearance for burner removal and service.
  - 2. Install AGA-approved flexible connectors.
- F. Hydronic Piping Connections:
  - 1. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
  - 2. Install shutoff valve and union or flange on each supply connection, and install balancing valve and union or flange on each return connection.
- G. Duct Connections:
  - 1. Comply with requirements in Section 233113 "Metal Ducts."
  - 2. Drawings indicate the general arrangement of ducts.
  - 3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."

### **3.4 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.

### **3.5 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."

### 3.6 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Inspect units for visible damage to furnace combustion chamber.
3. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:
  - a. Measure gas pressure at manifold.
  - b. Measure combustion-air temperature at inlet to combustion chamber.
  - c. Measure flue-gas temperature at furnace discharge.
  - d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
  - e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
4. Verify operation of remote panel, including pilot-light operation and failure modes. Inspect the following:
  - a. High-limit heat exchanger.
  - b. Alarms.
5. Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.
6. Start refrigeration system when outdoor-air temperature is within normal operating limits. and measure and record the following:
  - a. Cooling coil leaving-air, dry- and wet-bulb temperatures.
  - b. Cooling coil entering-air, dry- and wet-bulb temperatures.
  - c. Condenser coil entering-air dry-bulb temperature.
  - d. Condenser coil leaving-air dry-bulb temperature.
7. Simulate maximum cooling demand and inspect the following:
  - a. Compressor refrigerant suction and hot-gas pressures.
  - b. Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.
8. Inspect casing insulation for integrity, moisture content, and adhesion.
9. Verify that clearances have been provided for servicing.
10. Verify that controls are connected and operable.
11. Verify that filters are installed.
12. Clean coils and inspect for construction debris.
13. Clean furnace flue and inspect for construction debris.
14. Inspect operation of power vents.
15. Purge gas line.
16. Inspect and adjust vibration isolators and seismic restraints.

17. Verify bearing lubrication.
18. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
19. Adjust fan belts to proper alignment and tension.
20. Start unit.
21. Inspect and record performance of interlocks and protective devices, including response to smoke detectors by fan controls and fire alarm.
22. Operate unit for run-in period.
23. Calibrate controls.
24. Adjust and inspect high-temperature limits.
25. Inspect outdoor-air dampers for proper stroke and interlock with return-air damper.
26. Verify operational sequence of controls.
27. Measure and record the following airflows. Plot fan volumes on fan curve.
  - a. Supply-air volume.
  - b. Relief-air flow.
  - c. Outdoor-air flow.

- B. After startup, change filters, verify bearing lubrication, and adjust belt tension.
- C. Remove and replace components that do not properly operate, and repeat startup procedures as specified above.
- D. Prepare written report of the results of startup services.

### **3.7 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 four full seasons 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.

### **3.8 CLEANING**

- A. After completing system installation; testing, adjusting, and balancing dedicated outdoor-air unit and air-distribution systems; and completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, casings, dampers, coils, and filter housings, and install new, clean filters.

### **3.9 FIELD QUALITY CONTROL**

- A. Testing Agency: 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 the following tests and inspections:
  - 1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
  - 2. Charge refrigerant coils with refrigerant and test for leaks.
  - 3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

### **3.10 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

**END OF SECTION**

## **SECTION 238219 - FAN COIL UNITS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

A. Section Includes:

1. Ductless fan coil units.
2. Ducted fan coil units.

#### **1.2 ACTION SUBMITTALS**

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. 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.

#### **1.3 INFORMATIONAL SUBMITTALS**

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which fan coil units will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:
  - a. Lighting fixtures.
  - b. Air outlets and inlets.
  - c. Speakers.
  - d. Sprinklers.
  - e. Access panels.
6. Perimeter moldings.

- B. Field quality-control reports.

#### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals.

#### **1.5 QUALITY ASSURANCE**

- A. Comply with NFPA 70.

#### **1.6 COORDINATION**

- A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate size and location of wall sleeves for outdoor-air intake.

#### **1.7 WARRANTY**

- A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Compressor failure.
    - b. Condenser coil leak.
  - 2. Warranty Period: Four years from date of Substantial Completion.

### **PART 2 - PRODUCTS**

#### **2.1 SYSTEM DESCRIPTION**

- 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. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

#### **2.2 DUCTLESS FAN COIL UNITS**

- A. Fan Coil Unit Configurations: Row split.



1. Number of Heating Coils: One with two-pipe system.
  2. Number of Cooling Coils: same coil as heating coil.
- B. Coil Section Insulation:
1. 1/2-inch- thick, matte-finish, closed-cell foam complying with ASTM C1071 and attached with adhesive complying with ASTM C916.
  2. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
  3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Drain Pans: Main and Auxiliary Plastic. Fabricate pans and drain connections to comply with ASHRAE 62.1.
- D. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel. Floor-mounting units shall have leveling screws.
- E. Cabinet: Steel with baked-enamel finish in manufacturer's standard paint color as selected by Architect.
1. Vertical Unit Front Panels: Removable, steel, with steel discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
  2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped discharge grilles.
  3. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by Architect from manufacturer's standard colors. Return grille shall provide maintenance access to fan coil unit.
  4. Steel recessing flanges for recessing fan coil units into ceiling or wall.
- F. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
1. MERV Rating: 6 when tested according to ASHRAE 52.2.
- G. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.
- H. Factory, Hydronic Piping Package: copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
1. Three-way, modulating control valve for dual-temperature coil.
  2. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.

3. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
  4. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A126, Class B); 125-psig working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 hose-end, full-port, ball-type blowdown valve in drain connection.
- I. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- J. Basic Unit Controls:
1. Control voltage transformer.
  2. Wall-mounting thermostat with the following features:
    - a. Heat-cool-off switch.
    - b. Fan on-auto switch.
    - c. Fan-speed switch.
    - d. Adjustable deadband.
    - e. Exposed set point.
    - f. Exposed indication.
    - g. Degree F indication.
  3. Data entry and access port.
    - a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
    - b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
- K. Interface with DDC System for HVAC Requirements:
1. Interface relay for scheduled operation.
  2. Interface relay to provide indication of fault at the central workstation.
  3. Provide BACnet interface for central DDC system for HVAC workstation for the following functions:
    - a. Adjust set points.
    - b. Fan coil unit start, stop, and operating status.
    - c. Data inquiry, including room-air temperature and humidity.
    - d. Occupied and unoccupied schedules.
- L. Electrical Connection: Factory wire motors and controls for a single electrical connection.

## **2.3 DUCTED FAN COIL UNITS**

- A. Fan Coil Unit Configurations: Row split.
  - 1. Number of Heating Coils: One with two-pipe system.
  - 2. Number of Cooling Coils: same coil as heating coil.
- B. Coil Section Insulation:
  - 1. 1/2-inch- thick, coated glass fiber complying with ASTM C1071 and attached with adhesive complying with ASTM C916.
  - 2. Insulate coil section according to Section 230716 "HVAC Equipment Insulation."
- C. Drain Pans: Main and Auxiliary Plastic. Fabricate pans and drain connections to comply with ASHRAE 62.1.
- D. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel. Floor-mounting units shall have leveling screws.
- E. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
  - 1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis.
  - 2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
- F. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
- G. MERV Rating: 6 when tested according to ASHRAE 52.2.
- H. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.
- I. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
  - 1. Motors: Comply with requirements in Section 230500 "Common Work Results for HVAC."
- J. Factory, Hydronic Piping Package: copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
  - 1. Two-way, modulating control valve for chilled water / hot water combined coil.
  - 2. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.

3. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
  4. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A126, Class B); 125-psig working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 hose-end, full-port, ball-type blowdown valve in drain connection.
- K. Remote condensing units are specified in Section 236200 "Packaged Compressor and Condenser Units."
- L. Control devices and operational sequence are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
- M. Interface with DDC System for HVAC Requirements:
1. Interface relay for scheduled operation.
  2. Interface relay to provide indication of fault at the central workstation.
  3. Provide BACnet interface for central DDC system for HVAC workstation for the following functions:
    - a. Adjust set points.
    - b. Fan coil unit start, stop, and operating status.
    - c. Data inquiry, including room-air temperature.
    - d. Occupied and unoccupied schedules.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION OF FAN COIL UNITS**

- A. Install fan coil units level and plumb.
- B. Install fan coil units to comply with NFPA 90A.

- C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
- D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices above finished floor.
- E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

### **3.3 CONNECTIONS**

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
  - 1. Install piping adjacent to machine to allow service and maintenance.
  - 2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
  - 3. Connect condensate drain to indirect waste.
    - a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.
- B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.
- 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."

### **3.4 FIELD QUALITY CONTROL**

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Remove and replace malfunctioning units and retest as specified above.
- C. Prepare test and inspection reports.

### **3.5 ADJUSTING**

- A. Adjust initial temperature and humidity set points.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to visits to Project during other-than-normal occupancy hours for this purpose.

General Headquarters Complex  
Renovations to Interior/Exterior & Install Emergency Generator  
Multiple Assets  
Jefferson City, MO

State Project Number: R2502-01

### **3.6 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain fan coil units.

**END OF SECTION**

## **SECTION 26 0500 - COMMON WORK RESULTS FOR ELECTRICAL**

### **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. Electrical equipment coordination and installation.
  - 2. Sleeves for raceways and cables.
  - 3. Sleeve seals.
  - 4. Grout.
  - 5. Common electrical installation requirements.

#### **1.3 DEFINITIONS**

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

#### **1.4 COORDINATION**

- A. Coordinate arrangement, mounting, and support of electrical equipment:
  - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
  - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
  - 3. To allow right of way for piping and conduit installed at required slope.
  - 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".

## **PART 2 - PRODUCTS**

### **2.1 SLEEVES FOR RACEWAYS AND CABLES**

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel.
  - 1. Minimum Metal Thickness:
    - a. For sleeve cross-section rectangle perimeter, less than 50 inches) and no side more than 16 inches), thickness shall be 0.052 inch.
    - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches thickness shall be 0.138 inch.

### **2.2 SLEEVE SEALS**

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Advance Products & Systems, Inc.
    - b. Calpico, Inc.
    - c. Metraflex Co.
    - d. Pipeline Seal and Insulator, Inc.
    - e. Thunderline Link-Seal, Model C (Basis of Design Product).
  - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
  - 3. Pressure Plates: Reinforced nylon polymer. Include two for each sealing element.
  - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.



## **2.3 GROUT**

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

## **PART 3 - EXECUTION**

### **3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION**

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.

### **3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS**

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches above finished floor level.
- G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
- J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work. Penetrations of existing roofing systems shall comply with methods and materials approved by the roofing system manufacturer.
- L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

### **3.3 SLEEVE-SEAL INSTALLATION**

- A. Install to seal exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

### **3.4 FIRESTOPPING**

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

### **END OF SECTION 260500**

## **SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES**

### **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 the following:
  - 1. Building wires and cables rated 600 V and less.
  - 2. Connectors, splices, and terminations rated 600 V and less.
  - 3. Sleeves and sleeve seals for cables.

#### **1.3 DEFINITIONS**

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

#### **1.4 QUALITY ASSURANCE**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

#### **1.5 COORDINATION**

- A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

## **PART 2 - PRODUCTS**

### **2.1 CONDUCTORS AND CABLES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Alcan Products Corporation; Alcan Cable Division.
  - 2. American Insulated Wire Corp.; a Leviton Company.
  - 3. General Cable Corporation.
  - 4. Senator Wire & Cable Company.
  - 5. Southwire Company.
- B. Copper Conductors: Comply with NEMA WC 70.
- C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN or XHHW.
- D. Multiconductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC with ground wire and type HCF (Healthcare Facility) MC with ground wire for Hospital patient care areas.

### **2.2 CONNECTORS AND SPLICES**

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. AFC Cable Systems, Inc.
  - 2. Hubbell Power Systems, Inc.
  - 3. O-Z/Gedney; EGS Electrical Group LLC.
  - 4. 3M; Electrical Products Division.
  - 5. Tyco Electronics Corp.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

### **2.3 SLEEVES FOR CABLES**

- A. See specification Section 260500.

### **2.4 SLEEVE SEALS**

- A. See Specification Section 260500.

## **PART 3 - EXECUTION**

### **3.1 CONDUCTOR MATERIAL APPLICATIONS**

- A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

### **3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS**

- A. Service Entrance: Type THHN-THWN, single conductors in raceway.
- B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- E. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway; or Metal-clad cable, Type MC. Type MC cable shall be used for non-emergency applications only and shall be HCF (HealthCare Facility) rated when installed in Hospital patient care areas per NEC Article 517.13. Type MC cable shall be allowed from the device, light fixture, equipment, etc. served to a j-box above an accessible ceiling. Home runs from the j-box to the panelboard and branch circuits between j-boxes shall be single conductors in raceway.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

### **3.3 INSTALLATION OF CONDUCTORS AND CABLES**

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- B. 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.
- C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."
- F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

### **3.4 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 and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
  - 1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

### **3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS**

- A. See Specification Section 260500.

### **3.6 SLEEVE-SEAL INSTALLATION**

- A. See Specification Section 260500.

### **3.7 FIRESTOPPING**

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

### **3.8 FIELD QUALITY CONTROL**

- A. Perform tests and inspections and prepare test reports.
- B. 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. Emergency system feeders.
  - b. HVAC equipment feeders.
2. Perform each visual and mechanical inspection and electrical test stated in ANSI/NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
  - 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 splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- C. Test Reports: Prepare a written report to record the following:
  1. Test procedures used.
  2. Test results that comply with requirements.
  3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D. Remove and replace malfunctioning units and retest as specified above.

**END OF SECTION 260519**

## **SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

### **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: Grounding systems and equipment.

### **PART 2 - PRODUCTS**

#### **2.1 CONDUCTORS**

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
  - 1. Solid Conductors: ASTM B 3.
  - 2. Stranded Conductors: ASTM B 8.
  - 3. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
  - 4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
  - 5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V. Determine bus length in field or as indicated on the drawings.

#### **2.2 CONNECTORS**

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.



1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

## **2.3 GROUNDING ELECTRODES**

- A. Ground Rods: Copper; 3/4 inch by 10 feet.

## **PART 3 - EXECUTION**

### **3.1 APPLICATIONS**

- A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
  1. Bury at least 24 inches below grade.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Grounding Bus: Install in telephone/data equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
  1. Install bus on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
- E. Conductor Terminations and Connections:
  1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
  2. Underground Connections: Welded connection.
  3. Connections to Ground Rods: Welded connection.
  4. Connections to Structural Steel: Welded connection.

### **3.2 EQUIPMENT GROUNDING**

- A. Install insulated equipment grounding conductors with all 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. Metal-clad cable runs.
  - 8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
  - 9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
- 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 a 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. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
  - 1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
  - 2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch grounding bus.
  - 3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- F. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

### 3.3 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

- B. Ground Rods: Drive rods until tops are 2 inches 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. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- 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. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- D. Grounding and Bonding for Piping:
  - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
  - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
  - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- E. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- F. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

### **3.4 FIELD QUALITY CONTROL**

- A. Perform the following 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 a calibrated torque wrench according to manufacturer's written instructions.
  3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.
    - a. Measure ground resistance at least for two full days after last trace of precipitation and without soil being moistened by any 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 according to IEEE 81.
- B. Grounding system will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.
- D. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
  2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
  3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
  4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm.
  5. Pad-Mounted Equipment: 5 ohms.
- E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

**END OF SECTION 26 0526**

## **SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**

### **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 the following:
  - 1. Hangers and supports for electrical equipment and systems.
  - 2. Construction requirements for concrete bases.
- B. Related Sections include the following:
  - 1. Division 26 Section "Vibration And Seismic Controls For Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

#### **1.3 DEFINITIONS**

- A. EMT: Electrical metallic tubing.
- B. RMC: Rigid metal conduit.

#### **1.4 PERFORMANCE REQUIREMENTS**

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

#### **1.5 SUBMITTALS**

- A. Product Data: For the following:

1. Steel slotted support systems.

## **1.6 QUALITY ASSURANCE**

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

## **1.7 COORDINATION**

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."
- C. Coordinate with other trades for piping and duct runs.

## **PART 2 - PRODUCTS**

### **2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS**

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Allied Tube & Conduit.
    - b. Cooper B-Line, Inc.; a division of Cooper Industries.
    - c. ERICO International Corporation.
    - d. GS Metals Corp.
    - e. Thomas & Betts Corporation.
    - f. Unistrut; Atkore
    - g. Wesanco, Inc.
  2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
  3. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
  4. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

- C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
  - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
    - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - 1) Hilti Inc.
      - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      - 3) MKT Fastening, LLC.
      - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
  - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
    - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
      - 2) Empire Tool and Manufacturing Co., Inc.
      - 3) Hilti Inc.
      - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      - 5) MKT Fastening, LLC.
  - 3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
  - 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
  - 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
  - 6. Toggle Bolts: All-steel springhead type.
  - 7. Hanger Rods: Threaded steel.

## **2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES**

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

## **PART 3 - EXECUTION**

### **3.1 APPLICATION**

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
  - 1. Secure raceways and cables to these supports with single-bolt conduit clamps.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

### **3.2 SUPPORT INSTALLATION**

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
  - 1. To Wood: Fasten with lag screws or through bolts.



2. To New Concrete: Bolt to concrete inserts.
  3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  4. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
  5. To Light Steel: Sheet metal screws.
  6. 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 meet seismic-restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

### **3.3 INSTALLATION OF FABRICATED METAL SUPPORTS**

- A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

### **3.4 CONCRETE BASES**

- A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use **3000-psi**, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete".
- C. Anchor equipment to concrete base.
  1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  2. Install anchor bolts to elevations required for proper attachment to supported equipment.
  3. Install anchor bolts per anchor-bolt manufacturer's written instructions.

### **3.5 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 minimum dry film thickness of 2.0 mils..
- B. Touchup: Comply with requirements in Division 09 for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

**END OF SECTION 26 0529**

## **SECTION 26 0533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS**

### **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 raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- B. Related Sections include the following:
  - 1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

#### **1.3 DEFINITIONS**

- A. EMT: Electrical metallic tubing.
- B. FMC: Flexible metal conduit.
- C. LFMC: Liquidtight flexible metal conduit.
- D. LFNC: Liquidtight flexible nonmetallic conduit.
- E. NBR: Acrylonitrile-butadiene rubber.
- F. RNC: Rigid nonmetallic conduit.
- G. RMC: Rigid Metal Conduit

#### **1.4 SUBMITTALS**

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
  - 1. Custom enclosures and cabinets.

2. For handholes and boxes for underground wiring, including the following:
  - a. Duct entry provisions, including locations and duct sizes.
  - b. Frame and cover design.
  - c. Grounding details.
  - d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
- C. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
  1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    - a. The term "withstand" means "the cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, after the seismic event."
  2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

## **1.5 QUALITY ASSURANCE**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

## **PART 2 - PRODUCTS**

### **2.1 METAL CONDUIT AND TUBING**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. AFC Cable Systems, Inc.
  2. Alflec Inc.
  3. Allied Tube & Conduit; a Tyco International Ltd. Co.
  4. Anamet Electrical, Inc.; Anaconda Metal Hose.
  5. Electri-Flex Co.
  6. Manhattan/CDT/Cole-Flex.

7. Maverick Tube Corporation.
  8. O-Z Gedney; a unit of General Signal.
  9. Wheatland Tube Company.
- B. Rigid Steel Conduit: ANSI C80.1.
- C. Aluminum Rigid Conduit: ANSI C80.5.
- D. EMT: ANSI C80.3.
- E. FMC: Zinc-coated steel.
- F. LFMC: Liquidtight flexible steel conduit with PVC jacket.
- G. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
1. Fittings for EMT: Steel, set-screw type.
- H. Joint Compound for Rigid Steel Conduit: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

## **2.2 NONMETALLIC CONDUIT AND TUBING**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems, Inc.
  2. Anamet Electrical, Inc.; Anaconda Metal Hose.
  3. Arnco Corporation.
  4. CANTEX Inc.
  5. CertainTeed Corp.; Pipe & Plastics Group.
  6. Condux International, Inc.
  7. ElecSYS, Inc.
  8. Electri-Flex Co.
  9. Lamson & Sessions; Carlon Electrical Products.
  10. Manhattan/CDT/Cole-Flex.
  11. RACO; a Hubbell Company.
  12. Thomas & Betts Corporation.
- B. ENT: NEMA TC 13.
- C. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.
- D. LFNC: UL 1660.

- E. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.
- F. Fittings for LFNC: UL 514B.

## **2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Arnco Corporation.
  - 2. Endot Industries Inc.
  - 3. IPEX Inc.
  - 4. Lamson & Sessions; Carlon Electrical Products.
- B. Description: Comply with UL 2024; flexible type, approved for plenum, riser, or general-use installation as dictated by field conditions and applicable codes.

## **2.4 METAL WIREWAYS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Cooper B-Line, Inc.
  - 2. Hoffman.
  - 3. Square D; Schneider Electric.
- B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.
- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type.
- E. Finish: Manufacturer's standard enamel finish.

## **2.5 SURFACE RACEWAYS**

- A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Thomas & Betts Corporation.
    - b. Walker Systems, Inc.; Wiremold Company (The).

- c. Wiremold Company (The); Electrical Sales Division.
- d. Hubbell Wiring Device-Kellems

## **2.6 BOXES, ENCLOSURES, AND CABINETS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
  - 2. EGS/Appleton Electric.
  - 3. Erickson Electrical Equipment Company.
  - 4. Hoffman.
  - 5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
  - 6. RACO; a Hubbell Company.
  - 7. Thomas & Betts Corporation.
- B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, aluminum, Type FD, with gasketed cover.
- D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
- E. Metal Floor Boxes: Sheet metal, fully adjustable, rectangular.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- G. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.
- H. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
  - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  - 2. Nonmetallic Enclosures: Plastic.
- I. Cabinets:
  - 1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
  - 2. Hinged door in front cover with flush latch and concealed hinge.
  - 3. Key latch to match panelboards.
  - 4. Metal barriers to separate wiring of different systems and voltage.
  - 5. Accessory feet where required for freestanding equipment.

## **2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING**

- A. Description: Comply with SCTE 77.

1. Color of Frame and Cover: Gray.
  2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
  3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
  4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
  5. Cover Legend: Molded lettering, as indicated on the drawings for each service.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Strongwell Quazite or a comparable product by one of the following:
    - a. Armorcast Products Company.
    - b. Carson Industries LLC.
    - c. CDR Systems Corporation.
    - d. NewBasis.

## **2.8 SLEEVES FOR RACEWAYS**

- A. See Specification Section 260500.

## **2.9 SLEEVE SEALS**

- A. See Specification Section 260500.

# **PART 3 - EXECUTION**

## **3.1 RACEWAY APPLICATION**

- A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
1. Exposed Conduit: Rigid aluminum conduit.
  2. Concealed Conduit, Aboveground: EMT.
  3. Underground Conduit: RNC, Type EPC-80-PVC, direct buried.
  4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
  5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
  6. Application of Handholes and Boxes for Underground Wiring:
    - a. Handholes and Pull Boxes 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.



- b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer-concrete units, SCTE 77, Tier 8 structural load rating.
- B. Comply with the following indoor applications, unless otherwise indicated:
  - 1. Exposed, Not Subject to Physical Damage: EMT.
  - 2. Exposed, Not Subject to Severe Physical Damage: EMT.
  - 3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
    - a. Loading dock.
    - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
  - 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
  - 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
  - 6. Damp or Wet Locations: Rigid steel conduit.
  - 7. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway
  - 8. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Riser-type, optical fiber/communications cable raceway.
  - 9. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: General-use, optical fiber/communications cable raceway.
  - 10. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, nonmetallic in damp or wet locations.
- C. Minimum Raceway Size: **3/4-inch** trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
  - 1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
- E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.
- F. Do not install aluminum conduits in contact with concrete.

### 3.2 INSTALLATION

- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.

- D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- H. Raceways Embedded in Slabs:
  - 1. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
  - 2. Change from ENT to rigid steel conduit before rising above the floor.
- I. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- L. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:
  - 1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
  - 2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
  - 3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
  - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
  - 2. Where otherwise required by NFPA 70.
- N. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semirecessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
  2. Use LFMC in damp or wet locations not subject to severe physical damage.
- O. 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.
- P. Set metal floor boxes level and flush with finished floor surface.

### **3.3 INSTALLATION OF UNDERGROUND CONDUIT**

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Division 31 Section "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
  - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
  - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

### **3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES**

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a 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.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes and boxes with bottom below the frost line, 30" below grade.

**3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS**

- A. See Specification Section 260500.

**3.6 SLEEVE-SEAL INSTALLATION**

- A. See Specification Section 260500.

**3.7 FIRESTOPPING**

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

**3.8 PROTECTION**

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
  - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
  - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

**END OF SECTION 26 0533**

## **SECTION 26 0548 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS**

### **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 the following:
  - 1. Isolation pads.
  - 2. Spring isolators.
  - 3. Restrained spring isolators.
  - 4. Channel support systems.
  - 5. Restraint cables.
  - 6. Hanger rod stiffeners.
  - 7. Anchorage bushings and washers.
- B. Related Sections include the following:
  - 1. Division 26 Section "Hangers And Supports For Electrical Systems" for commonly used electrical supports and installation requirements.

#### **1.3 DEFINITIONS**

- A. The IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

#### **1.4 SUBMITTALS**

- A. Product Data: For the following:
  - 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
  - 2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

- a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
    - b. Annotate to indicate application of each product submitted and compliance with requirements.
  3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.
- B. Delegated-Design Submittal: For seismic-restraint details 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 static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
    - a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 Sections for equipment mounted outdoors.
  2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
  3. Field-fabricated supports.
  4. Seismic-Restraint Details:
    - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
    - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events
    - c. 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).
- C. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.
- D. Welding certificates.
- E. Qualification Data: For professional engineer and testing agency.
- F. Field quality-control test reports.

## **1.5 QUALITY ASSURANCE**

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
- E. Comply with NFPA 70.

## **PART 2 - PRODUCTS**

### **2.1 VIBRATION ISOLATORS**

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
  - 1. Ace Mountings Co., Inc.
  - 2. Amber/Booth Company, Inc.
  - 3. California Dynamics Corporation.
  - 4. Isolation Technology, Inc.
  - 5. Kinetics Noise Control.
  - 6. Mason Industries.
  - 7. Vibration Eliminator Co., Inc.
  - 8. Vibration Isolation.
  - 9. Vibration Mountings & Controls, Inc.

- D. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
  - 1. Resilient Material: Oil- and water-resistant **neoprene**.
- E. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
  - 1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  - 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  - 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  - 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  - 5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch-thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
  - 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- F. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
  - 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch-thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
  - 2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
  - 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  - 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  - 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  - 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

## 2.2 SEISMIC-RESTRAINT DEVICES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
  - 1. Amber/Booth Company, Inc.
  - 2. California Dynamics Corporation.



3. Cooper B-Line, Inc.; a division of Cooper Industries.
  4. Hilti Inc.
  5. Loos & Co.; Seismic Earthquake Division.
  6. Mason Industries.
  7. TOLCO Incorporated; a brand of NIBCO INC.
  8. Unistrut; Tyco International, Ltd.
- D. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- E. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with 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; and rated in tension, compression, and torsion forces.
- F. Restraint Cables: ASTM A 603 galvanized steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
- G. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod. Do not weld stiffeners to rods.
- H. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.
- I. 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.
- J. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- K. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
- L. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl 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 E 488.

## **2.3 FACTORY FINISHES**

- A. Finish: Manufacturer's standard prime-coat finish ready for field painting.
- B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
  - 1. Powder coating on springs and housings.
  - 2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
  - 3. Baked enamel or powder coat for metal components on isolators for interior use.
  - 4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas and equipment to receive seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 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 hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

### **3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION**

- A. Equipment and Hanger Restraints:
  - 1. Install restrained isolators on electrical equipment.
  - 2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
  - 3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

- B. 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.
- C. 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.
- D. Drilled-in 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 the 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 Anchors: 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 Anchors: 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.

### **3.4 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 they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

### **3.5 FIELD QUALITY CONTROL**

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Perform tests and inspections.
- C. 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 post connection 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 at least 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.
  6. Measure isolator restraint clearance.
  7. Measure isolator deflection.
  8. Verify snubber minimum clearances.
  9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

### **3.6 ADJUSTING**

- A. Adjust isolators after isolated equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

**END OF SECTION 26 0548**

## **SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS**

### **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. Identification for raceways.
  - 2. Identification of power and control cables.
  - 3. Identification for conductors.
  - 4. Underground-line warning tape.
  - 5. Warning labels and signs.
  - 6. Instruction signs.
  - 7. Equipment identification labels.
  - 8. Miscellaneous identification products.

#### **1.3 QUALITY ASSURANCE**

- A. Comply with ANSI 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. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

#### **1.4 COORDINATION**

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

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

## **PART 2 - PRODUCTS**

### **2.1 POWER RACEWAY IDENTIFICATION MATERIALS**

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at 600 V or Less:
  - 1. Black letters on an orange field.
  - 2. Legend: Indicate voltage and system or service type.
- C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather-, UV and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

### **2.2 METAL-CLAD CABLE IDENTIFICATION MATERIALS**

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Colors for Raceways Carrying Circuits at 600 V and Less:
  - 1. Black letters on an orange field.
  - 2. Legend: Indicate voltage and system or service type.
- C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

### **2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS**

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

## **2.4 CONDUCTOR IDENTIFICATION MATERIALS**

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 3/4 to 2 inches wide.

## **2.5 FLOOR MARKING TAPE**

- A. 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

## **2.6 UNDERGROUND-LINE WARNING TAPE**

- A. Detectable Tape:
  - 1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
  - 2. Printing on tape shall be permanent and shall not be damaged by burial operations.
  - 3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
  - 4. Tape shall have a metallic core that is detectable by a metal detector. Verify the tape size required based on the width and depth of the underground lines.
- B. Color and Printing:
  - 1. Comply with ANSI Z535.1 through ANSI Z535.5.
  - 2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
  - 3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

## **2.7 WARNING LABELS AND SIGNS**

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
- C. Warning label and sign 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"

## **2.8 INSTRUCTION SIGNS**

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.
  - 1. Engraved legend with black letters on white face.
  - 2. Punched or drilled for mechanical fasteners.

## **2.9 EQUIPMENT IDENTIFICATION LABELS**

- A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

## **2.10 CABLE TIES**

- A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
  - 1. Minimum Width: 3/16 inch.
  - 2. Tensile Strength at 73 deg F, According to ASTM D 638: 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, Type 6/6 nylon.
  - 1. Minimum Width: 3/16 inch.
  - 2. Tensile Strength at 73 deg F, According to ASTM D 638: 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, self locking.
  - 1. Minimum Width: 3/16 inch.
  - 2. Tensile Strength at 73 deg F, According to ASTM D 638: 7000 psi.
  - 3. UL 94 Flame Rating: 94V-0.
  - 4. Temperature Range: Minus 50 to plus 284 deg F.
  - 5. Color: Black.

## **2.11 MISCELLANEOUS IDENTIFICATION PRODUCTS**

- A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select 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**

### **3.1 INSTALLATION**

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- F. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands 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.
- G. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
  - 1. Outdoors: UV-stabilized nylon.
  - 2. In Spaces Handling Environmental Air: Plenum rated.
- I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches overall.

### **3.2 IDENTIFICATION SCHEDULE**

- A. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Self-adhesive vinyl labels. Install labels at 30-foot maximum intervals.

- B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
  - 1. Emergency Power.
  - 2. Power.
  - 3. UPS.
- C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in pull and junction boxes, and handholes, use color-coding conductor tape to identify the phase.
  - 1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for service, feeder, and branch-circuit conductors.
    - a. Color shall be factory applied.
    - b. Colors for 208/120-V Circuits:
      - 1) Phase A: Black.
      - 2) Phase B: Red.
      - 3) Phase C: Blue.
      - 4) Neutral: White.
      - 5) Ground: Green.
    - c. Colors for 480/277-V Circuits:
      - 1) Phase A: Brown.
      - 2) Phase B: Orange.
      - 3) Phase C: Yellow.
      - 4) Neutral: Gray.
      - 5) Ground: Green.
    - d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
- E. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.
- F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
  - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
  - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.
- G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
  1. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- H. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.
  1. Comply with 29 CFR 1910.145.
  2. Identify system voltage with black letters on an orange background.
  3. Apply to exterior of door, cover, or other access.
  4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
    - a. Power transfer switches.
    - b. Controls with external control power connections.
- J. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
  1. Labeling Instructions:
    - a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. 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.
    - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
    - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
    - d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
  2. Equipment to Be Labeled:

- a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved, laminated acrylic or melamine label.
- b. Enclosures and electrical cabinets.
- c. Access doors and panels for concealed electrical items.
- d. Switchboards.
- e. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
- f. Emergency system boxes and enclosures.
- g. Motor-control centers.
- h. Enclosed switches.
- i. Enclosed circuit breakers.
- j. Enclosed controllers.
- k. Variable-speed controllers.
- l. Push-button stations.
- m. Power transfer equipment.
- n. Contactors.
- o. Remote-controlled switches, dimmer modules, and control devices.
- p. Power-generating units.
- q. Monitoring and control equipment.
- r. UPS equipment.

**END OF SECTION 26 0553**

## **SECTION 260573 – SHORT CIRCUIT, OVERCURRENT PROTECTIVE DEVICE COORDINATION, AND ARC FLASH STUDIES**

### **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 computer-based, fault-current, overcurrent protective device coordination, and arc-flash studies. Protective devices shall be set based on results of the protective device coordination study.
  - 1. Coordination of series-rated devices is permitted where indicated on Drawings.

#### **1.3 SUBMITTALS**

- A. Product Data: For computer software program to be used for studies.
- B. Qualification Data: For power system study specialist.
- C. Product Certificates: For power system computer software programs, certifying compliance with IEEE 399, IEEE 1584 and NFPA 70E.
- D. Report Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals shall be in digital form.
  - 1. Equipment Evaluation Reports.
  - 2. Coordination-Study Report.
  - 3. Arc-Flash Study Report

#### **1.4 QUALITY ASSURANCE**

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.
- B. Power Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. Professional engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.
- C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.
- D. Comply with IEEE 399 for general study procedures.
- E. Comply with IEEE 1584 and NFPA 70E for arc-flash study procedures.

## **PART 2 - PRODUCTS**

### **2.1 COMPUTER SOFTWARE DEVELOPERS**

- A. Available Computer Software Developers: Subject to compliance with requirements, companies offering computer software programs that may be used in the Work include, but are not limited to, the following:
  1. EDSA Micro Corporation.
  2. ESA Inc.
  3. SKM Systems Analysis, Inc.
  4. EasyPower, LLC

### **2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS**

- A. Comply with IEEE 399 and IEEE 1584.
- B. Analytical features of fault-current-study computer software program shall include "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. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
  1. Features:
    - a. Arcing faults.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
  - 1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

### **3.2 POWER SYSTEM DATA**

- A. Gather and tabulate the following input data to support coordination study:
  - 1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
  - 2. Impedance of utility service entrance.
  - 3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:
    - a. Circuit-breaker and fuses: manufacturer and model, current ratings, types and settings.
    - b. Relays and associated power and current transformer ratings and ratios.
    - c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
    - d. Generator kilovolt amperes, size, voltage, and source impedance.
    - e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
    - f. Busway manufacturer and model, ampacity and impedance, length and conductor material.
    - g. Motor horsepower and code letter designation according to NEMA MG 1.
    - h. Derating factors.
    - i. Voltage at each bus.
  - 4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
    - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.

- c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
- d. Generator thermal-damage curve.
- e. Ratings, types, and settings of utility company's overcurrent protective devices.
- f. Special overcurrent protective device settings or types stipulated by utility company.
- g. Time-current-characteristic curves of devices indicated to be coordinated.
- h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
- i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
- j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

### 3.3 FAULT-CURRENT STUDY

- A. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:
  - 1. Switchgear and switchboard bus.
  - 2. Motor-control center.
  - 3. Distribution panelboard.
  - 4. Branch circuit panelboard.
- B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.
- C. Calculate momentary and interrupting duties on the basis of maximum available fault current.
- D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with and IEEE 242.
  - 1. Transformers:
    - a. ANSI C57.12.22.
  - 2. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.
  - 3. Low-Voltage Fuses: IEEE C37.46.
- E. Study Report:
  - 1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.



F. Equipment Evaluation Report:

1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
3. 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.

### 3.4 COORDINATION STUDY

- A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.
  1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
  2. Calculate the maximum and minimum ground-fault currents.
- B. Comply with IEEE 141 recommendations for fault currents and time intervals.
- C. Transformer Primary Overcurrent Protective Devices:
  1. Device shall not operate in response to the following:
    - a. Inrush current when first energized.
    - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
    - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
  2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
- D. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
- E. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:
  1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
    - a. Device tag.

- b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
    - c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
    - d. Fuse-current rating and type.
    - e. Ground-fault relay-pickup and time-delay settings.
  2. Time-Current Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
    - a. Device tag.
    - b. Voltage and current ratio for curves.
    - c. Three-phase and single-phase damage points for each transformer.
    - d. No damage, melting, and clearing curves for fuses.
    - e. Cable damage curves.
    - f. Transformer inrush points.
    - g. Maximum fault-current cutoff point.
- F. Completed data sheets for setting of overcurrent protective devices.

### **3.5 ARC-FLASH STUDY**

- A. Content
  1. Executive summary of study findings.
  2. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
  3. One-line diagram, showing the following:
    - a. Protective device designations and ampere ratings.
    - b. Conductor types, sizes, and lengths.
    - c. Transformer kilovolt ampere (kVA) and voltage ratings, including derating factors and environmental conditions.
    - d. Motor and generator designations and kVA ratings.
    - e. Switchgear, switchboard, motor-control center, panelboard designations, and ratings.
    - f. Derating factors and environmental conditions.
    - g. Any revisions to electrical equipment required by the study.
  4. Arc-Flash Study Output.
    - a. Arc-flash boundary.
    - b. Restricted approach boundary.
    - c. Limited approach boundary.

- d. Working distance.
- e. Incident energy.
- f. Hazard risk category.

**B. Arc-Flash Warning Labels**

1. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis.
2. Label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
  - a. Location designation.
  - b. Nominal voltage.
  - c. Protection boundaries.
    - 1) Arc-flash boundary.
    - 2) Restricted approach boundary.
    - 3) Limited approach boundary.
  - d. Arc flash PPE category.
  - e. Required minimum arc rating of PPE in Cal/cm squared.
  - f. Available incident energy.
  - g. Working distance.
  - h. Engineering report number, revision number, and issue date.
3. Labels shall be machine printed, with no field-applied markings.

**3.6 LABELING**

- A. Apply one arc-flash label for, 480-V ac, and 208-V ac panelboards and disconnects and for each of the following locations:
1. Motor-control center.
  2. Low-voltage switchboard.
  3. Switchgear.
  4. Medium-voltage switch.
  5. Medium voltage transformers
  6. Low voltage transformers. Exclude transformers with high voltage side 240 V or less and less than 125 kVA.
  7. Panelboard and safety switch over 250 V.
  8. Applicable panelboard and safety switch under 250 V.
  9. Control panel.

### **3.7 APPLICATION OF WARNING LABELS**

- A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

**END OF SECTION 26 0573**

## **SECTION 260923 - LIGHTING CONTROL DEVICES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes the following lighting control devices:
  - 1. Time switches.
  - 2. Outdoor and indoor photoelectric switches.
  - 3. Indoor occupancy sensors.
- B. Related Sections include the following:
  - 1. Division 26 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

#### **1.3 DEFINITIONS**

- A. LED: Light-emitting diode.
- B. PIR: Passive infrared.

#### **1.4 SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show installation details for occupancy and light-level sensors.
  - 1. Interconnection diagrams showing field-installed wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

## **1.5 QUALITY ASSURANCE**

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

## **1.6 COORDINATION**

- 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 system, and partition assemblies.

## **PART 2 - PRODUCTS**

### **2.1 TIME SWITCHES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Intermatic, Inc., ET70000 Series
  - 2. Paragon Electric Co.; Invensys Climate Controls.
  - 3. TORK.

### **2.2 OUTDOOR PHOTOELECTRIC SWITCHES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Intermatic, Inc., K4100 Series
  - 2. Paragon Electric Co.; Invensys Climate Controls.
  - 3. TORK.
- B. Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten or 1000-VA ballast, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
  - 1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
  - 2. Time Delay: 15-second minimum, to prevent false operation.
  - 3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
  - 4. Mounting: Stem mounting, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

## 2.3 INDOOR OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell Lighting.
  2. Leviton Mfg. Company Inc.
  3. Lithonia Lighting; Acuity Lighting Group, Inc.
  4. Novitas, Inc.
  5. RAB Lighting, Inc.
  6. Sensor Switch, Inc.
  7. TORK.
  8. Watt Stopper (The).
- B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
1. Ceiling Mounted Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
  2. Wall Mounted Operation: Unless otherwise indicated, manual on and automatic off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
  3. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
  4. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
  5. Mounting:
    - a. Sensor: Suitable for mounting in any position on a standard 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.
  6. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
  7. Bypass Switch: Override the on function in case of sensor failure.
  8. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; keep lighting off when selected lighting level is present.
- C. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Technology or combination of technologies that controls on-off functions shall be 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. in., and detect a person of

- average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/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.

## **PART 3 - EXECUTION**

### **3.1 SENSOR INSTALLATION**

- A. 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 written instructions.

### **3.2 WIRING INSTALLATION**

- A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 3/4 inch.
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

### **3.3 IDENTIFICATION**

- A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
  1. Identify controlled circuits in lighting contactors.
- B. Label time switches and contactors with a unique designation.

### **3.4 FIELD QUALITY CONTROL**

- A. Perform the following field tests and inspections and prepare test reports:
  1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
  2. Operational Test: Verify operation of each lighting control device, and adjust time delays.



- B. Lighting control devices that fail tests and inspections are defective work and shall be replaced to comply with the manufacturers specifications.

### **3.5 DEMONSTRATION**

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

**END OF SECTION 26 0923**

## **SECTION 262416 - PANELBOARDS**

### **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. Distribution panelboards.
  - 2. Lighting and appliance branch-circuit panelboards.

#### **1.3 DEFINITIONS**

- A. SVR: Suppressed voltage rating.
- B. TVSS: Transient voltage surge suppressor.

#### **1.4 PERFORMANCE REQUIREMENTS**

- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
  - 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."

#### **1.5 SUBMITTALS**

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
  - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.

2. Detail enclosure types and details for types other than NEMA 250, Type 1.
  3. Detail bus configuration, current, and voltage ratings.
  4. Short-circuit current rating of panelboards and overcurrent protective devices.
  5. Include evidence of NRTL listing for series rating of installed devices.
  6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  7. Include wiring diagrams for power, signal, and control wiring.
  8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.
- C. Qualification Data: For qualified testing agency.
- D. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
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.
- E. Field Quality-Control Reports:
1. Test procedures used.
  2. Test results that comply with requirements.
  3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- F. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
  2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

## **1.6 QUALITY ASSURANCE**

- A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- 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.

## **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Remove loose packing and flammable materials from inside panelboards.
- B. Handle and prepare panelboards for installation according to NECA 407 and NEMA PB 1.

## **1.8 PROJECT CONDITIONS**

- A. Environmental Limitations:
  - 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
  - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
    - a. Ambient Temperature: Not exceeding **23** deg F to plus 104 deg F.
    - b. Altitude: Not exceeding 6600 feet.
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
  - 1. Ambient temperatures within limits specified.
  - 2. Altitude not exceeding 6600 feet.
- C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
  - 1. Notify Construction Manager and Owner no fewer than seven days in advance of proposed interruption of electric service.
  - 2. Do not proceed with interruption of electric service without Construction Manager's and Owner's written permission.
  - 3. Comply with NFPA 70E.

## **1.9 COORDINATION**

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment,

raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

## **1.10 WARRANTY**

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Manufacturers standard warranty period from date of Substantial Completion.

## **1.11 EXTRA MATERIALS**

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Keys: Two spares for each type of panelboard cabinet lock.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL REQUIREMENTS FOR PANELBOARDS**

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Enclosures: Flush and surface-mounted cabinets.
  - 1. Rated for environmental conditions at installed location.
    - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
    - b. Outdoor Locations: NEMA 250, Type 3R.
    - c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
    - d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
  - 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
  - 3. Hinged Door: Standard hinged door within front trim cover.

4. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
  5. Finishes:
    - a. Panels and Trim: 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: Galvanized steel.
    - c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
  6. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
- C. Incoming Mains Location: Field verify location for each panelboard.
- D. Phase, Neutral, and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
  2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
- E. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
  2. Main and Neutral Lugs: Mechanical type.
  3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
  4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
  5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
- F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

## **2.2 DISTRIBUTION PANELBOARDS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide Square D or comparable product by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

- 3. Siemens Energy & Automation, Inc.
- C. Panelboards: NEMA PB 1, power and feeder distribution type.
- D. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
  - 1. For doors more than 36 inches high, provide two latches, keyed alike.
- E. Mains: Circuit breaker or Main Lug Only as indicated on the drawings.
- F. Branch Overcurrent Protective Devices for Circuit-Breakers: Bolt-on circuit breakers.

## **2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide Square D, Schneider Electric or comparable product by one of the following:
  - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  - 3. Siemens Energy & Automation, Inc.
- C. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- D. Mains: Circuit breaker or Main Lug Only as indicated on the drawings.
- E. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

## **2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide Square D, Schneider Electric or comparable product by one of the following:
  - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  - 3. Siemens Energy & Automation, Inc.
- C. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current 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.
2. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
3. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
4. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
  - a. Standard frame sizes, trip ratings, and number of poles.
  - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
  - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
  - d. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
  - e. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
  - f. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

## **2.5 PANELBOARD SUPPRESSORS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide Square D, Schneider Electric or comparable product by one of the following:
  1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  3. Siemens Energy & Automation, Inc.
- C. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, plug-in, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:
  1. Accessories:
    - a. Fuses rated at 200-kA interrupting capacity.
    - b. Fabrication using bolted compression lugs for internal wiring.
    - c. Integral disconnect switch.
    - d. Redundant suppression circuits.
    - e. Redundant replaceable modules.
    - f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.



- g. LED indicator lights for power and protection status.
  - h. Audible alarm, with silencing switch, to indicate when protection has failed.
  - i. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
  - j. Four-digit, transient-event counter set to totalize transient surges.
- 2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.
- 3. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
- 4. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 and 208Y/120-V, three-phase, four-wire circuits shall be as follows:
  - a. Line to Neutral: 800 V for 480Y/277 and 400 V for 208Y/120.
  - b. Line to Ground: 800 V for 480Y/277 and 400 V for 208Y/120.
  - c. Neutral to Ground: 800 V for 480Y/277 and 400 V for 208Y/120.
- 5. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:
  - a. Line to Line: 2000 V for 480 V and 1000 V for 240 V.
  - b. Line to Ground: 1500 V for 480 V and 800 V for 240 V.

## **2.6 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**

### **3.1 EXAMINATION**

- A. Receive, inspect, handle, and store panelboards according to NECA 407 and NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install panelboards and accessories according to NECA 407 and NEMA PB 1.1.
- B. Equipment Mounting: Install panelboards on concrete bases, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."
  - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
  - 2. For panelboards, 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 panelboards.
  - 5. Attach panelboard to the vertical finished or structural surface behind the panelboard.
  - 6. All penetrations through the existing hollow core floor slab shall be entirely located in the hollow core portion of the slab. Scan the floor slab to locate the hollow cores prior to penetration.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- E. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- G. Install overcurrent protective devices and controllers not already factory installed.
  - 1. Set field-adjustable, circuit-breaker trip ranges.
- H. Install filler plates in unused spaces.
- I. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future.
- J. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- K. Comply with NECA 1.

### **3.3 IDENTIFICATION**

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

### **3.4 FIELD QUALITY CONTROL**

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
  - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- C. Tests and Inspections:
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. 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 an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
    - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
    - c. Instruments and Equipment:
      - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- D. Panelboards will be considered defective if they do not pass tests and inspections.

- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### **3.5 ADJUSTING**

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

**END OF SECTION 26 2416**

## **SECTION 262726 - WIRING DEVICES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Straight-blade convenience, and tamper-resistant receptacles.
  - 2. GFCI receptacles.
  - 3. Toggle switches.
  - 4. Wall switch sensor light switches with dual technology sensors.
  - 5. Wall plates.
  - 6. Prefabricated multioutlet assemblies.

#### **1.3 DEFINITIONS**

- A. Abbreviations of Manufacturers' Names:
  - 1. Cooper: Cooper Wiring Devices; Division of Cooper Industries, Inc.
  - 2. Hubbell: Hubbell Incorporated: Wiring Devices-Kellems.
  - 3. Leviton: Leviton Mfg. Company, Inc.
  - 4. Pass & Seymour: Pass& Seymour/Legrand.
- B. BAS: Building automation system.
- C. EMI: Electromagnetic interference.
- D. GFCI: Ground-fault circuit interrupter.
- E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- F. RFI: Radio-frequency interference.
- G. SPD: Surge protective device.
- H. UTP: Unshielded twisted pair.

#### **1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Shop Drawings: List of legends and description of materials and process used for marking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.

#### **1.5 INFORMATIONAL SUBMITTALS**

- A. Field quality-control reports.

#### **1.6 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

### **PART 2 - PRODUCTS**

#### **2.1 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 application.
- B. Comply with NFPA 70.
- C. Devices for Owner-Furnished Equipment:
  - 1. Receptacles: Match plug configurations.
  - 2. Cord and Plug Sets: Match equipment requirements.
- D. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.
- E. Provide devices with right angle pigtailed snap connect terminals.

#### **2.2 STRAIGHT-BLADE RECEPTACLES**

- A. Tamper-Resistant Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Eaton (Arrow Hart).
  - b. Hubbell Incorporated; Wiring Device-Kellems.
  - c. Leviton Manufacturing Co., Inc.
  - d. Pass & Seymour/Legrand (Pass & Seymour).
2. Description: Labeled and complying with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.
  3. Provide device with right angle pigtailed snap connect terminal.

## 2.3 GFCI RECEPTACLES

### A. General Description:

1. 125 V, 20 A, straight blade, feed through type.
2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.
4. Provide device with right angle pigtailed snap connect terminal.

### B. Duplex GFCI Convenience Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Eaton (Arrow Hart).
  - b. Hubbell Incorporated; Wiring Device-Kellems.
  - c. Leviton Manufacturing Co., Inc.
  - d. Pass & Seymour/Legrand (Pass & Seymour).

### C. Tamper-Resistant, Duplex GFCI Convenience Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Hubbell Incorporated; Wiring Device-Kellems.
  - b. Pass & Seymour/Legrand (Pass & Seymour).

## 2.4 CORD AND PLUG SETS

### A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

## 2.5 TOGGLE SWITCHES

- A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

- B. Switches, 120/277 V, 20 A:

1. Single Pole:

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

- 1) Eaton (Arrow Hart).
- 2) Hubbell Incorporated; Wiring Device-Kellems.
- 3) Leviton Manufacturing Co., Inc.
- 4) Pass & Seymour/Legrand (Pass & Seymour).

2. Two Pole:

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

- 1) Eaton (Arrow Hart).
- 2) Hubbell Incorporated; Wiring Device-Kellems.
- 3) Leviton Manufacturing Co., Inc.
- 4) Pass & Seymour/Legrand (Pass & Seymour).

3. Three Way:

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

- 1) Eaton (Arrow Hart).
- 2) Hubbell Incorporated; Wiring Device-Kellems.
- 3) Leviton Manufacturing Co., Inc.
- 4) Pass & Seymour/Legrand (Pass & Seymour).

4. Four Way:

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

- 1) Eaton (Arrow Hart).
- 2) Hubbell Incorporated; Wiring Device-Kellems.
- 3) Leviton Manufacturing Co., Inc.
- 4) Pass & Seymour/Legrand (Pass & Seymour).



C. Pilot-Light Switches: 120/277 V, 20 A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Eaton (Arrow Hart).
  - b. Hubbell Incorporated; Wiring Device-Kellems.
  - c. Leviton Manufacturing Co., Inc.
  - d. Pass & Seymour/Legrand (Pass & Seymour).
2. Description: Single pole, with LED-lighted handle, illuminated when switch is off.

## 2.6 WALL SWITCH SENSOR LIGHT SWITCH, DUAL TECHNOLOGY

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Eaton (Arrow Hart).
  2. Hubbell Incorporated; Wiring Device-Kellems.
  3. Leviton Manufacturing Co., Inc.
  4. Pass & Seymour/Legrand (Pass & Seymour).
  5. Watt Stopper.
  6. Sensor Switch, Acuity Brands.
- B. Description: Switchbox-mounted, combination lighting-control sensor and conventional switch lighting-control unit using dual technology.
  1. Connections: Provisions for connection to BAS.
  2. Connections: Hard wired.
  3. Connections: Wireless.
  4. Rated 960 W at 120-V ac for tungsten lighting, 10 A at 120-V ac or 10 A at 277-V ac for fluorescent or LED lighting, and 1/4 hp at 120-V ac.
  5. Adjustable time delay of up to 30 minutes.
  6. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc.
  7. Comply with NEMA WD 1, UL 20, and FS W-S-896.

## 2.7 OCCUPANCY SENSORS

- A. Wall-Switch Sensors (Single Relay):
  1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Hubbell; AD1277\*1 (\* denotes device color).
    - b. Leviton; OSSMT-MA.
    - c. Watt Stopper (The); DSW-100.

2. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1000 sq. ft.

B. Wall-Switch Sensors (Dual Relay):

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
  - a. Hubbell; AD1277\*2 (\* denotes device color).
  - b. Leviton; OSSMD-MA.
  - c. Watt Stopper (The); DW-200.
3. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, with a minimum coverage area of 1000 sq. ft.

C. Ceiling Occupancy Sensors:

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Leviton; OSC20-MAW.
  - b. Hubbell; LVDT2000R.
  - c. Watt Stopper (The); DT-355.

Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 360-degree field of view, with minimum coverage of 1000 sq. ft. Minimum switch rating: 1200-VA fluorescent.

## 2.8 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Smooth, high-impact thermoplastic.
3. Material for Unfinished Spaces: Smooth, high-impact thermoplastic.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Wet-Location, Weatherproof "While-in-Use" Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with lockable cover.

C. Patient accessible areas for Behavioral Health spaces:

1. Plate-Securing Screws: Metal with tamper resistant head and center pin reject. Color to match plate finish.
2. Material for Behavioral Health: Smooth, nylon with reinforcement ribs.

3. Wall plates shall be provided that insure the grounding integrity of the entire installation.

## **2.9 PREFABRICATED MULTIOUTLET ASSEMBLIES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Hubbell Incorporated; Wiring Device-Kellems.
  2. Wiremold / Legrand.
- B. Description:
  1. Two-piece surface metal raceway, with factory-wired multioutlet harness.
  2. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
- C. Raceway Material: Metal, with manufacturer's standard finish.
- D. Multioutlet Harness:
  1. Receptacles: 15-A, 125-V, NEMA WD 6 Configuration 5-15R receptacles complying with NEMA WD 1, UL 498, and FS W-C-596.
  2. Receptacle Spacing: as shown on the drawings
  3. Wiring: No. 12 AWG solid, Type THHN copper.
  4. Factory finish color shall be as selected by the architect.

## **2.10 FINISHES**

- A. Device Color:
  1. Wiring Devices Connected to Normal Power System: As selected by Architect, unless otherwise indicated or required by NFPA 70 or device listing.
  2. Wiring Devices Connected to Emergency Power System: Red.
- B. Wall Plate Color: Match device color.

## **PART 3 - EXECUTION**

### **3.1 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 meet provisions of 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. Pigtail 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.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

- 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. Provide tamper resistant device plates in all patient areas of Behavioral Health Department.
- G. Dimmers:
  - 1. Install dimmers within terms of their listing.
  - 2. Verify that dimmers used for fan-speed control are listed for that application.
  - 3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
- H. 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.
- I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

### **3.2 GFCI RECEPTACLES**

- A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.
- B. Provide GFCI, Tamper Resistant receptacles in all patient accessible areas of Behavioral Health Department.

### **3.3 IDENTIFICATION**

- A. Comply with Section 260553 "Identification for Electrical Systems."
- B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

### **3.4 FIELD QUALITY CONTROL**

- A. Test Instruments: Use instruments that comply with UL 1436.
- B. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- C. Perform the following tests and inspections:
  - 1. Prepare reports that comply with recommendations in NFPA 99.
  - 2. Test Instruments: Use instruments that comply with UL 1436.

3. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- D. Tests for Convenience 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. Test straight-blade hospital-grade convenience outlets for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz..
- F. Wiring device will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports and submit to owner.

**END OF SECTION 262726**

## **SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Fusible switches.
  - 2. Nonfusible switches.
  - 3. Molded-case circuit breakers (MCCBs).
  - 4. Enclosures.

#### **1.3 DEFINITIONS**

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

#### **1.4 PERFORMANCE REQUIREMENTS**

- A. Seismic Performance: Enclosed switches and circuit breakers 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 from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### **1.5 SUBMITTALS**

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
  - 1. Enclosure types and details for types other than NEMA 250, Type 1.

2. Current and voltage ratings.
  3. Short-circuit current ratings (interrupting and withstand, as appropriate).
  4. Include evidence of NRTL listing for series rating of installed devices.
  5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
- B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
1. Wiring Diagrams: For power, signal, and control wiring.
- C. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

## **1.6 QUALITY ASSURANCE**

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source 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 as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NFPA 70.

## **1.7 PROJECT CONDITIONS**

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
  2. Altitude: Not exceeding 6600 feet (2010 m).
- B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:



1. Notify Construction Manager and Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Construction Manager's and Owner's written permission.
4. Comply with NFPA 70E.

## **1.8 COORDINATION**

- A. 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.

## **PART 2 - PRODUCTS**

### **2.1 FUSIBLE SWITCHES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  3. Siemens Energy & Automation, Inc.
  4. Square D; a brand of Schneider Electric.
- B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle (open and closed positions) 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.
  5. Service-Rated Switches: Labeled for use as service equipment.

### **2.2 NONFUSIBLE SWITCHES**

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  3. Siemens Energy & Automation, Inc.
  4. Square D; a brand of Schneider Electric.
- B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle (open and closed positions) 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.

## **2.3 MOLDED-CASE CIRCUIT BREAKERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  3. Siemens Energy & Automation, Inc.
  4. Square D; a brand of Schneider Electric.
- B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- C. Thermal-Magnetic Circuit Breakers: Inverse time-current 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.
- D. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- E. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
- F. 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.
  3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.

## **2.4 ENCLOSURES**

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
  - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
  - 2. Outdoor Locations: NEMA 250, Type 3R.
  - 3. Kitchen and Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
  - 4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
  - 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

## **PART 3 - EXECUTION**

### **3.1 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.

### **3.2 INSTALLATION**

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in fusible devices.
- E. Comply with NECA 1.

### **3.3 IDENTIFICATION**

- A. Comply with requirements in Division 26 Section "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.

### **3.4 FIELD QUALITY CONTROL**

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
  - 1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- C. Tests and Inspections:
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. 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 an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
    - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
    - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - 4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### **3.5 ADJUSTING**

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

**END OF SECTION 262816**

## **SECTION 262913 - ENCLOSED CONTROLLERS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. Section includes the following enclosed controllers rated 600 V and less:
  - 1. Full-voltage manual.
  - 2. Full-voltage magnetic.
- B. Related Section:
  - 1. Division 26 Section "Variable-Frequency Motor Controllers" for general-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.

#### **1.3 DEFINITIONS**

- A. CPT: Control power transformer.
- B. MCCB: Molded-case circuit breaker.
- C. MCP: Motor circuit protector.
- D. N.C.: Normally closed.
- E. N.O.: Normally open.
- F. OCPD: Overcurrent protective device.
- G. SCR: Silicon-controlled rectifier.

#### **1.4 PERFORMANCE REQUIREMENTS**

- A. Seismic Performance: Enclosed controllers 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 from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

## 1.5 SUBMITTALS

- A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.
- B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.
  1. Show tabulations of the following:
    - a. Each installed unit's type and details.
    - b. Factory-installed devices.
    - c. Nameplate legends.
    - d. Short-circuit current rating of integrated unit.
    - e. Listed and labeled for integrated short-circuit current (withstand) rating of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.
    - f. Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.
  2. Wiring Diagrams: For power, signal, and control wiring.
- C. Qualification Data: For qualified testing agency.
- D. Seismic Qualification Certificates: For enclosed controllers, 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.
- E. Field quality-control reports.
- F. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
  1. Routine maintenance requirements for enclosed controllers and installed components.
- G. 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.

## **1.6 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. Comply with NFPA 70.
- C. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

## **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 250 W per controller.

## **1.8 PROJECT CONDITIONS**

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
  - 1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
  - 2. Altitude: Not exceeding 6600 feet (2010 m).
- B. Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
  - 1. Notify Construction Manager and Owner no fewer than seven days in advance of proposed interruption of electrical systems.
  - 2. Indicate method of providing temporary utilities.
  - 3. Do not proceed with interruption of electrical systems without Construction Manager's and Owner's written permission.
  - 4. Comply with NFPA 70E.

## **1.9 COORDINATION**

- A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

## **1.10 EXTRA MATERIALS**

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. 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. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

## **PART 2 - PRODUCTS**

### **2.1 FULL-VOLTAGE CONTROLLERS**

- A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.
- B. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle 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. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    - c. Siemens Energy & Automation, Inc.
    - d. Square D; a brand of Schneider Electric.
    - e. Allen Bradley
  - 2. Configuration: Nonreversing.
  - 3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 20 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; melting alloy type.
  - 4. Surface mounting.



5. Red pilot light.
- C. Magnetic Controllers: Full voltage, across the line, electrically held.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    - c. Siemens Energy & Automation, Inc.
    - d. Square D; a brand of Schneider Electric.
    - e. Allen Bradley
  2. Configuration: Nonreversing.
  3. Contactor Coils: Pressure-encapsulated type.
    - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
  4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
  5. Control Circuits: 24-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
    - a. CPT Spare Capacity: 50 VA.
  6. Melting Alloy Overload Relays:
    - a. Inverse-time-current characteristic.
    - b. Class 20 tripping characteristic.
    - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
  7. N.C., isolated overload alarm contact.
  8. External overload reset push button.
  9. Selector Switch: Hand-Off-Auto (HOA).
  10. Pilot Light: Red
  11. Auxiliary Contacts: One normally open and one normally closed.
- D. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    - c. Siemens Energy & Automation, Inc.

- d. Square D; a brand of Schneider Electric.
- 2. Fusible Disconnecting Means:
  - a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class R fuses.
  - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
  - c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
- 3. Nonfusible Disconnecting Means:
  - a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
  - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
  - c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
- 4. MCP Disconnecting Means:
  - a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
  - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
  - c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
  - d. N.C. alarm contact that operates only when MCP has tripped.
  - e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

## **2.2 ENCLOSURES**

- A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.
  - 1. Dry and Clean Indoor Locations: Type 1.
  - 2. Outdoor Locations: Type 3R.
  - 3. Kitchen and Wash-Down Areas: Type 4X, stainless steel.
  - 4. Other Wet or Damp Indoor Locations: Type 4.
  - 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

## **2.3 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: Heavy-duty type.
  - a. Push Buttons: Shrouded types; maintained as indicated.
  - b. Pilot Lights: LED types; colors as indicated; push to test.
  - c. Selector Switches: Rotary type, Hand-Off-Auto.
- B. One N.C. and one N.O. auxiliary contact(s).
- C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.
- D. Spare control wiring terminal blocks, quantity as indicated; wired.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
- B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION**

- A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise 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 Division 26 Section "Hangers and Supports for Electrical Systems."
- B. Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in each fusible-switch enclosed controller.
- E. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."
- F. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

- H. Comply with NECA 1.

### **3.3 IDENTIFICATION**

- A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
  - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
  - 2. Label each enclosure with engraved nameplate.
  - 3. Label each enclosure-mounted control and pilot device.

### **3.4 CONTROL WIRING INSTALLATION**

- A. Install wiring between enclosed controllers and remote devices.
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control selection devices where applicable.

### **3.5 FIELD QUALITY CONTROL**

- A. Acceptance Testing Preparation:
  - 1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- B. Tests and Inspections:
  - 1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
  - 2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
  - 3. Test continuity of each circuit.
  - 4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer before starting the motor(s).
  - 5. Test each motor for proper phase rotation.
  - 6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  - 8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

- a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multi-pole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
  - b. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- 9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Enclosed controllers will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### **3.6 ADJUSTING**

- A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

### **3.7 PROTECTION**

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
- B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

### **END OF SECTION 262913**

## **SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS**

### **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 separately enclosed, pre-assembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

#### **1.3 DEFINITIONS**

- A. BAS: Building automation system.
- B. CPT: Control power transformer.
- C. EMI: Electromagnetic interference.
- D. IGBT: Insulated-gate bipolar transistor.
- E. LAN: Local area network.
- F. LED: Light-emitting diode.
- G. MCP: Motor-circuit protector.
- H. NC: Normally closed.
- I. NO: Normally open.
- J. OCPD: Overcurrent protective device.
- K. PCC: Point of common coupling.
- L. PID: Control action, proportional plus integral plus derivative.
- M. PWM: Pulse-width modulated.
- N. RFI: Radio-frequency interference.

- O. TDD: Total demand (harmonic current) distortion.
- P. THD(V): Total harmonic voltage demand.
- Q. VFC: Variable-frequency motor controller.

#### **1.4 PERFORMANCE REQUIREMENTS**

- A. Seismic Performance: VFCs 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 from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### **1.5 SUBMITTALS**

- A. Product Data: For each type and rating of VFC indicated. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories.
- B. Shop Drawings: For each VFC indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
  - 1. Show tabulations of installed devices, equipment features, and ratings. Include the following:
    - a. Each installed unit's type and details.
    - b. Factory-installed devices.
    - c. Enclosure types and details.
    - d. Nameplate legends.
    - e. Short-circuit current (withstand) rating of enclosed unit.
    - f. Features, characteristics, ratings, and factory settings of each VFC and installed devices.
    - g. Specified modifications.
  - 2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.
- C. Seismic Qualification Certificates: For VFCs, 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.

- D. Product Certificates: For each VFC, from manufacturer.
- E. Source quality-control reports.
- F. Field quality-control reports.
- G. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
  - 1. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and MCP trip settings.
  - 2. Manufacturer's written instructions for setting field-adjustable overload relays.
  - 3. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
  - 4. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

## **1.6 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. Comply with NFPA 70.
- C. IEEE Compliance: Fabricate and test VFC according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

## **1.7 DELIVERY, STORAGE, AND HANDLING**

- A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

## **1.8 PROJECT CONDITIONS**

- A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:
  - 1. Ambient Temperature: Not less than 14 deg F (minus 10 deg C) and not exceeding 104 deg F (40 deg C).
  - 2. Ambient Storage Temperature: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C)
  - 3. Humidity: Less than 95 percent (noncondensing).



4. Altitude: Not exceeding 3300 feet (1005 m).
- B. Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
1. Notify Construction Manager and Owner no fewer than seven days in advance of proposed interruption of electrical systems.
  2. Indicate method of providing temporary electrical service.
  3. Do not proceed with interruption of electrical systems without Construction Manager's and Owner's written permission.
  4. Comply with NFPA 70E.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

## **1.9 COORDINATION**

- A. Coordinate features of motors, load characteristics, installed units, and accessory devices to be compatible with the following:
1. Torque, speed, and horsepower requirements of the load.
  2. Ratings and characteristics of supply circuit and required control sequence.
  3. Ambient and environmental conditions of installation location.
- B. Coordinate sizes and locations of equipment supports, and roof penetrations with actual equipment provided.

## **1.10 WARRANTY**

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Five years from date of Substantial Completion.

## **1.11 EXTRA MATERIALS**

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURED UNITS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. ABB.
  - 2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  - 3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  - 4. Rockwell Automation, Inc.; Allen-Bradley Brand.
  - 5. Siemens Energy & Automation, Inc.
  - 6. Square D; a brand of Schneider Electric, Altivar 61.
  - 7. Toshiba International Corporation, Series Q9.
- B. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.
- C. Application: Variable torque.
- D. VFC Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
  - 1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General-Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
  - 2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
  - 3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
- E. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- F. Output Rating: Three-phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
- G. Unit Operating Requirements:
  - 1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
  - 2. Input AC Voltage Unbalance: Not exceeding 3 percent.
  - 3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
  - 4. Minimum Efficiency: 96 percent at 60 Hz, full load.

5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
  6. Minimum Short-Circuit Current (Withstand) Rating: 100 kA.
  7. Ambient Temperature Rating: Not less than 14 deg F (minus 10 deg C) and not exceeding 104 deg F (40 deg C).
  8. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C)
  9. Humidity Rating: Less than 95 percent (noncondensing).
  10. Altitude Rating: Not exceeding 3300 feet (1005 m).
  11. Vibration Withstand: Comply with IEC 60068-2-6.
  12. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
  13. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
  14. Speed Regulation: Plus or minus 5 percent.
  15. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
  16. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
  17. Damper Permissive Function: Integral circuit.
- H. Inverter Logic: Microprocessor based, isolated from all power circuits.
- I. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
1. Signal: Electrical.
- J. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
  2. Maximum Speed: 80 to 100 percent of maximum rpm.
  3. Acceleration: 0.1 to 999.9 seconds.
  4. Deceleration: 0.1 to 999.9 seconds.
  5. Current Limit: 30 to minimum of 150 percent of maximum rating.
- K. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
  2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
  3. Under- and overvoltage trips.
  4. Inverter overcurrent trips.
  5. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
  6. Critical frequency rejection, with three selectable, adjustable deadbands.
  7. Instantaneous line-to-line and line-to-ground overcurrent trips.
  8. Loss-of-phase protection.

9. Reverse-phase protection.
  10. Short-circuit protection.
  11. Motor overtemperature fault.
- L. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
- M. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.
- N. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- O. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- P. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- Q. Integral Input Disconnecting Means and OCPD: NEMA AB 1, instantaneous-trip circuit breaker with pad-lockable, door-mounted handle mechanism.
1. Disconnect Rating: Not less than 115 percent of VFC input current rating.
  2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
  3. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.
  4. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
  5. NO alarm contact that operates only when circuit breaker has tripped.

## **2.2 CONTROLS AND INDICATION**

- A. Status Lights: Door-mounted LED indicators displaying the following conditions:
1. Power on.
  2. Run.
  3. Overvoltage.
  4. Line fault.
  5. Overcurrent.
  6. External fault.
- B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
  2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
    - a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.
- C. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
  2. Running log of total power versus time.
  3. Total run time.
  4. Fault log, maintaining last four faults with time and date stamp for each.
- D. Indicating Devices: Digital display mounted flush in VFC door and connected to display VFC parameters including, but not limited to:
1. Output frequency (Hz).
  2. Motor speed (rpm).
  3. Motor status (running, stop, fault).
  4. Motor current (amperes).
  5. Motor torque (percent).
  6. Fault or alarming status (code).
  7. PID feedback signal (percent).
  8. DC-link voltage (V dc).
  9. Set point frequency (Hz).
  10. Motor output voltage (V ac).
- E. Control Signal Interfaces:
1. Electric Input Signal Interface:
    - a. A minimum of two programmable analog inputs: 0- to 10-V dc.
    - b. A minimum of six multifunction programmable digital inputs.
  2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:
    - a. 0- to 10-V dc.
    - b. 4- to 20-mA dc.
    - c. Potentiometer using up/down digital inputs.
    - d. Fixed frequencies using digital inputs.
  3. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc), which can be configured for any of the following:

- a. Output frequency (Hz).
  - b. Output current (load).
  - c. DC-link voltage (V dc).
  - d. Motor torque (percent).
  - e. Motor speed (rpm).
  - f. Set point frequency (Hz).
4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
  - a. Motor running.
  - b. Set point speed reached.
  - c. Fault and warning indication (overtemperature or overcurrent).
  - d. PID high- or low-speed limits reached.
- F. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms and energy usage. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.
  1. Network Communications Ports: Ethernet and RS-422/485
  2. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet and Modbus/Memobus; protocols accessible via the communications ports.

## **2.3 LINE CONDITIONING AND FILTERING**

- A. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

## **2.4 OPTIONAL FEATURES**

- A. Damper control circuit with end of travel feedback capability.
- B. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.
- C. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.
- D. Remote digital operator kit.
- E. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

## **2.5 ENCLOSURES**

- A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
  2. Outdoor Locations: Type 3R.
  3. Kitchen and Wash-Down Areas: Type 4X, stainless steel.
  4. Other Wet or Damp Indoor Locations: Type 4.
- B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

## **2.6 ACCESSORIES**

- A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.
1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty type.
    - a. Push Buttons: Shrouded types; maintained.
    - b. Pilot Lights: LED types.
    - c. Selector Switches: Rotary type.
    - d. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- B. Reversible NC/NO bypass contactor auxiliary contact(s).
- C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.
- D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.
- E. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
- F. Spare control-wiring terminal blocks: wired.

## **2.7 SOURCE QUALITY CONTROL**

- A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.
1. Test each VFC while connected to its specified motor.
  2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

- B. VFCs will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance.
- B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Wall-Mounting Controllers: Install VFCs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."
- C. Floor-Mounting Controllers: Install VFCs on 4-inch (100-mm) nominal thickness concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."
  - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
  - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- D. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished roof surface



unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.

1. Curbs and roof penetrations are specified in Division 07 Section "Roof Accessories."
  2. Structural-steel channels are specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- E. Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- F. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- G. Install fuses in control circuits if not factory installed.
- H. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- I. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- J. Comply with NECA 1.

### **3.3 IDENTIFICATION**

- A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
  2. Label each VFC with engraved nameplate.
  3. Label each enclosure-mounted control and pilot device.
- B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

### **3.4 CONTROL WIRING INSTALLATION**

- A. Install wiring between VFCs and remote devices.
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

### **3.5 FIELD QUALITY CONTROL**

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
  1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Acceptance Testing Preparation:
  1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
  2. Test continuity of each circuit.
- D. Tests and Inspections:
  1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
  2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
  3. Test continuity of each circuit.
  4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer before starting the motor(s).
  5. Test each motor for proper phase rotation.
  6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
    - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
    - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
    - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

- E. VFCs will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

### **3.6 STARTUP SERVICE**

- A. Engage a factory-authorized service representative to perform startup service.
  1. Complete installation and startup checks according to manufacturer's written instructions.

### **3.7 ADJUSTING**

- A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
- B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Engineer before increasing settings.
- D. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."
- E. Set field-adjustable pressure switches.

### **3.8 PROTECTION**

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.
- B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

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Renovations to Interior/Exterior & Install Emergency Generator  
Multiple Assets  
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### **3.9 DEMONSTRATION**

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

**END OF SECTION 26 2923**

## **SECTION 263213.13 - DIESEL EMERGENCY ENGINE GENERATORS**

### **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 packaged diesel engine generators for emergency use with the following features:
  - 1. Diesel engine.
  - 2. Diesel fuel-oil system including tank.
  - 3. Control and monitoring.
  - 4. Generator overcurrent and fault protection.
  - 5. Generator, exciter, and voltage regulator.
  - 6. Load banks.
  - 7. Outdoor engine generator enclosure.
  - 8. Remote radiator motors.
  - 9. Vibration isolation devices.
  - 10. Finishes.
- 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.

#### **1.3 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.

#### **1.4 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 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.

## 1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Manufacturer and Installer

B. 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, external silencer, subbase-mounted fuel tank, 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.

C. 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.
- D. Field quality-control reports.
- E. Warranty: For special warranty.

## **1.6 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.

## **1.7 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
  2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
  3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
  4. Tools: Each tool listed by part number in operations and maintenance manual.

## **1.8 QUALITY ASSURANCE**

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
- B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

## **1.9 WARRANTY**

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace, at no cost to the owner, components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Manufacturers standard period from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Caterpillar, Inc.; Electric Power Division.
  2. Cummins Power Generation.
  3. Kohler Power Systems.
- B. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

### **2.2 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
  3. Component Importance Factor: 1.5.
- 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 applicable state and local government requirements.
- F. Noise Emission: 75dB for maximum noise level at adjacent property boundaries due to sound emitted by engine generator, including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.
- G. 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.

## **2.3 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 application.
- C. Power Factor: 0.8, lagging.
- D. Frequency: 60 Hz
- E. Voltage: 480 V ac.
- F. Phase: Three-phase, four-wire, wye.
- G. Governor: Adjustable isochronous, with speed sensing.
- H. 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.
  - 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.
- I. 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.

J. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage, from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency, from no load to full load.
4. 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.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10 system requirements.

K. 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: Comply with NFPA 110, Type 10, system requirements.

## **2.4 DIESEL ENGINE**

- A. Fuel: ASTM D 975 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 NFPA 110 requirements for Level 1 equipment for heater capacity and with UL 499.
- E. 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-, 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. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator set mounting frame and integral engine-driven coolant pump.
  - 1. Configuration: Horizontal air discharge.
  - 2. Radiator Core Tubes: Aluminum.
  - 3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
  - 4. Fan: Driven by multiple belts from engine shaft.
  - 5. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
  - 6. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
- G. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
  - 1. Minimum sound attenuation of 25 dB at 500 Hz.
  - 2. Sound level measured at property boundary from exhaust discharge after installation is complete shall be 75 dBA or less.
- H. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- I. Starting System: 24 V 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".
  - 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 and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
  - 7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
  - 8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.

9. 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.

## **2.5 DIESEL FUEL-OIL SYSTEM**

- A. Comply with NFPA 30.
- B. Piping: Fuel-oil piping shall be Schedule 40 black steel, complying with requirements in Section 231113 "Facility Fuel-Oil Piping." 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. Fuel-Oil Storage Tank: Include with generator package. Generator will mount on storage tank and supply 96 hours run time at full load conditions.

## **2.6 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. 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 engine generator 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 30 minutes, with override only by operation of a remote emergency-stop switch.
- D. Comply with UL 508A.
- E. Configuration: 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 engine generator vibration. Panel shall be powered from the engine generator battery.
- F. Configuration: 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.
- G. Control and Monitoring Panel:
  - 1. Digital controller with integrated LCD display, 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 as required by NFPA 110 for Level 2 system, 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 pre-alarm.
- 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 the duration required for the indicated EPSS class.

- m. Coolant low-level alarm.
- n. Coolant low-level shutdown device.
- o. Coolant high-temperature prealarm.
- p. Coolant high-temperature alarm.
- q. Coolant low-temperature alarm.
- r. Coolant high-temperature shutdown device.
- s. EPS load indicator.
- t. Battery high-voltage alarm.
- u. Low-cranking voltage alarm.
- v. Battery-charger malfunction alarm.
- w. Battery low-voltage alarm.
- x. Lamp test.
- y. Contacts for local and remote common alarm.
- z. Low-starting air pressure alarm.
- aa. Low-starting hydraulic pressure alarm.
- bb. Remote manual-stop shutdown device.
- cc. Air shutdown damper alarm when used.
- dd. Air shutdown damper shutdown device when used.
- ee. Generator overcurrent-protective-device not-closed alarm.

H. Connection to Datalink:

- 1. A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication.
- 2. Provide connections for datalink transmission of indications to remote data terminals via BACnet/ModBus. Data system connections to terminals are covered in Section 260913 "Electrical Power Monitoring and Control."

I. Common Remote Panel with Common Audible Alarm: Comply with NFPA 110 requirements for Level 2 systems. Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

J. Remote Alarm Annunciator: Comply with NFPA 99. An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

1. Overcrank alarm.
2. Coolant low-temperature alarm.
3. High engine temperature prealarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low-fuel main tank alarm.
8. Low coolant level alarm.
9. Low-cranking voltage alarm.
10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.
12. Air shutdown damper when used.
13. Run-Off-Auto switch.
14. Control switch not in automatic position alarm.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel-supply alarm.
17. Lamp test.
18. Low-cranking voltage alarm.
19. Generator overcurrent protective device not closed.

- K. 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.
- L. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

## **2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION**

- A. Main Overcurrent Protection Device: 600V, 1200A/3P, with LSIG (Long Time “Overload”, Short Time “Low-Level Short Circuits”, Intermediate “High-Level Short Circuits”, and Ground Fault “Earth Leakage”) functions.
- B. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device connected to the generator main circuit breaker shall open the circuit breaker to disconnect the generator from load circuits. Protector performs the following functions:
1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
  2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.



3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
  4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.
- C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.
1. Indicate ground fault with other engine generator alarm indications.

## **2.8 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 or Class F.
- D. Range: Provide broad range of output voltage by adjusting the excitation level.
- E. 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.
- F. Enclosure: Dripproof.
- G. Instrument Transformers: Mounted within generator enclosure.
- 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 10 percent and stabilize at rated frequency within five seconds.
- 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.
- K. Subtransient Reactance: 12 percent, maximum.

## **2.9 OUTDOOR ENGINE GENERATOR ENCLOSURE**

- A. Description: Vandal-resistant, sound-attenuating, weatherproof steel housing, wind resistant up to 100 mph. Multiple doors shall be lockable and provide adequate access to components requiring maintenance. Instruments and control shall be mounted within enclosure.
  - 1. Sound Attenuation Level: Level 3 sound attenuated.
- B. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads of up to 100 mph.
- C. Seismic Design: Comply with seismic requirements.
- D. Hinged Doors: With padlocking provisions.
- E. Space Heater: Thermostatically controlled and sized to prevent condensation.
- F. 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.
- G. Muffler Location: Within enclosure.
- H. 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. Storm-proof and drainable louvers prevent entry of rain and snow.
- I. 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-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.
  - 6. Minimum Deflection: 1 inch.
- B. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

## **2.11 FINISHES**

- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

## **2.12 SOURCE QUALITY CONTROL**

- A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
  - 1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
- B. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
  - 1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
  - 2. Test generator, exciter, and voltage regulator as a unit.
  - 3. Full-load run.
  - 4. Maximum power.
  - 5. Voltage regulation.
  - 6. Transient and steady-state governing.
  - 7. Single-step load pickup.
  - 8. Safety shutdown.
  - 9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
  - 10. Report factory test results within 10 days of completion of test.

## **PART 3 - EXECUTION**

### **3.1 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.

### **3.2 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 or Owner no fewer than 7 working days in advance of proposed interruption of electrical service.
  - 2. Do not proceed with interruption of electrical service without Construction Manager's and Owner's written permission.

### **3.3 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 restrained spring isolators having a minimum deflection of 1 inch on 4-inch-high concrete base. Secure base to anchor bolts installed in concrete. 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. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.
- F. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

### **3.4 CONNECTIONS**

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow space for service and maintenance.

- 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.
- E. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

### **3.5 IDENTIFICATION**

- A. Identify system components according to Section 260553 "Identification for Electrical Systems."

### **3.6 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.
  - 1. Perform tests recommended by manufacturer and in "Visual and Mechanical Inspection" and "Electrical and Mechanical Tests" subparagraphs below, as specified in the 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) Perform insulation-resistance tests according to IEEE 43.
        - a) Machines Larger Than 200 hp: Test duration shall be 10 minutes. Calculate polarization index.
        - b) Machines 200 hp or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.
      - 2) Test protective relay devices.
      - 3) Verify phase rotation, phasing, and synchronized operation as required by the application.
      - 4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
      - 5) Perform vibration test for each main bearing cap.
      - 6) Conduct performance test according to NFPA 110.

- 7) 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.
6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
7. Exhaust Emissions Test: Comply with applicable government test criteria.
8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
9. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
10. Noise-Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line and compare measured levels with required values.
- B. Coordinate tests with tests for transfer switches, and run them concurrently.
- C. 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.
- D. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.
- E. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.
- F. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- G. Remove and replace malfunctioning units and retest as specified above.

- H. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.
- I. 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.
- J. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels, so terminations 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 terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### **3.7 MAINTENANCE SERVICE**

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's authorized service representative. Include quarterly preventive maintenance and exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Parts shall be manufacturer's authorized replacement parts and supplies.

### **3.8 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 263213.13**

## **SECTION 263600 - TRANSFER SWITCHES**

### **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 transfer switches rated 600 V and less, including the following:
  - 1. Automatic transfer switches.
  - 2. Remote annunciation systems.

#### **1.3 SUBMITTALS**

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
  - 1. Single-Line Diagram: Show connections between transfer switch, power sources, and load.
- C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.



- D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
  - 1. Features and operating sequences, both automatic and manual.
  - 2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

#### **1.4 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.
- B. Source Limitations: Obtain automatic transfer switches, and remote annunciators through one source from a single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with NEMA ICS 1.
- E. Comply with NFPA 70.
- F. Comply with NFPA 99.
- G. Comply with NFPA 110.
- H. Comply with UL 1008 unless requirements of these Specifications are stricter.

#### **1.5 PROJECT CONDITIONS**

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:
  - 1. Notify Construction Manager and Owner 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 and Owner's written permission.

#### **1.6 COORDINATION**

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

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Transfer Switches:
    - a. Emerson; ASCO Power Technologies, LP.
    - b. GE Zenith Controls.
    - c. Russelectric, Inc.

### **2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS**

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, unless otherwise indicated.
- B. Tested Fault-Current Closing and Withstand 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.
- C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- F. 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 not acceptable.
  - 2. Switch Action: Double throw; mechanically held in both directions.
  - 3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
- G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

- H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
- I. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.
- J. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "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.
- K. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.
- L. Front Accessible Only: Switches shall be mounted against the wall. Switch components and maintenance tasks shall be wholly via front accessibility.

## **2.3 AUTOMATIC TRANSFER SWITCHES**

- A. Comply with Level 1 equipment according to NFPA 110.
- B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.
- D. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- E. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- F. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.
- G. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer

is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

H. Automatic Transfer-Switch Features:

1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
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 0 to 30 minutes, and factory set for 10 minutes to 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. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. 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 are adjustable from 10 to 30 minutes. Factory settings are 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 not available.

## **2.4 REMOTE ANNUNCIATOR SYSTEM**

- A. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:
  1. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
  2. Switch position.
  3. Switch in test mode.
  4. Failure of communication link.
- B. Annunciator Panel: LED-lamp type with audible signal and silencing switch.
  1. Indicating Lights: Grouped for each transfer switch monitored.
  2. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
  3. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
  4. Lamp Test: Push-to-test or lamp-test switch on front panel.

## **2.5 SOURCE QUALITY CONTROL**

- A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

# **PART 3 - EXECUTION**

## **3.1 INSTALLATION**

- A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Floor-Mounting Switch: Anchor to floor by bolting.
  1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."

- C. Annunciator Mounting: Flush in wall, unless otherwise indicated.
- D. Identify components according to Division 26 Section "Identification for Electrical Systems."
- E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

### **3.2 CONNECTIONS**

- A. Wiring to Remote Components: Match type and number of cables and conductors to 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. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

### **3.3 FIELD QUALITY CONTROL**

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform tests and inspections and prepare test reports.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
  - 2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
  - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 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, demonstrate interlocking sequence and operational function for each switch at least three times.
    - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.

- b. Simulate loss of phase-to-ground voltage for each phase of normal source.
  - c. Verify time-delay settings.
  - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
  - e. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
  - f. 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. Remove and replace malfunctioning units and retest as specified above.
- F. 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. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
  - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - 3. 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.

### **3.4 DEMONSTRATION**

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Division 01 Section "Demonstration and Training."
- B. Coordinate this training with that for generator equipment.

### **END OF SECTION 263600**

## **SECTION 265100 - INTERIOR LIGHTING**

### **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. Interior lighting fixtures, lamps, and ballasts.
  - 2. Emergency lighting units.
  - 3. Exit signs.
  - 4. Lighting fixture supports.
- B. Related Sections:
  - 1. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
  - 2. Division 26 Section "Wiring Devices" for manual wall-box dimmers for incandescent lamps.

#### **1.3 DEFINITIONS**

- A. BF: Ballast factor.
- B. CCT: Correlated color temperature.
- C. CRI: Color-rendering index.
- D. IP: International Protection or Ingress Protection Rating
- E. LED: Light emitting diode.
- F. LER: Luminaire efficacy rating.
- G. Lumen: Measured output of lamp and luminaire, or both.
- H. Luminaire: Complete lighting fixture, including ballast housing if provided.



#### **1.4 SUBMITTALS**

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
  - 1. Physical description of lighting fixture including dimensions.
  - 2. Emergency lighting units including battery and charger.
  - 3. “L” and “B” values identified for LEDs.
  - 4. Energy-efficiency data.
  - 5. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
  - 6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, drivers, and accessories identical to those indicated for the lighting fixture as applied in this Project.
  - 7. LED and driver product data.
- B. Shop Drawings: For nonstandard or custom lighting fixtures. Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- D. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.
- E. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
  - 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.
- F. Warranty: Sample of special warranty.

#### **1.5 QUALITY ASSURANCE**

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. 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 NFPA 70.

## **1.6 COORDINATION**

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

## **1.7 WARRANTY**

- A. 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 Lighting Unit Batteries: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.
- B. LED light fixture warranty shall be a minimum of 5 years from the manufacturer.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Products: Subject to compliance with requirements, provide one of the products indicated on the Light Fixture Schedule.

### **2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS**

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Metal Parts: Free of burrs and sharp corners and edges.
- C. LED sources: Ensure color consistency among luminaires as specified in lighting fixture schedule.
- D. Provide LEDs and drivers that are field replaceable without soldering.
- E. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
- F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit access to lamps and drivers without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during servicing and when secured in operating position.

G. Diffusers and Globes:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
  - a. Lens Thickness: See Light Fixture Schedule..
  - b. UV stabilized.

H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and drivers. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

## **2.3 EMERGENCY LED POWER UNIT**

- A. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with driver. Comply with UL 924.
1. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
    - a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    - b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
  2. Battery: Sealed, maintenance-free type.
  3. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.

## **2.4 LED LAMPS**

- A. See Light Fixture Schedule on the drawings.

## **2.5 LIGHTING FIXTURE SUPPORT COMPONENTS**

- A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.
- C. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

**A. Lighting fixtures:**

1. Set level, plumb, and square with ceilings and walls unless otherwise indicated per drawings .
2. Install lamps in each luminaire.

**B. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.**

1. Install support wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches from lighting fixture corners.
2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
4. Install two independent support wires from structure to tabs on lighting fixture. Wire shall have breaking strength of the weight of fixture at a safety factor of 3.

**C. Suspended Lighting Fixture Support:**

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Cable-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use cable for suspension for each unit length of fixture chassis, including one at each end.
4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.

### **3.2 IDENTIFICATION**

- A.** Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

### **3.3 FIELD QUALITY CONTROL**

- A.** Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

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### **3.4      STARTUP SERVICE**

- A.    Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner.

**END OF SECTION 265100**

## **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, abandoning site utilities in place.
  - 7. Temporary erosion and sedimentation control.
- B. Related Requirements:
  - 1. Section 015000 "Temporary Facilities and Controls" for temporary erosion- and sedimentation-control measures.
- C. Related Requirements:.
  - 1. Section 01500 "Temporary Facilities and Controls" for temporary erosion- and sedimentation-control measures.

#### **1.3 DEFINITIONS**

- A. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.
- B. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "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; the zone where plant roots grow.

- D. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction.
- E. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.
- F. Topsoil stripping and stockpiling program.
- G. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

#### **1.4 QUALITY ASSURANCE**

- A. Topsoil Stripping and Stockpiling Program: Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.

#### **1.5 FIELD 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 trafficways if required by Owner or authorities having jurisdiction.
- B. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.
- C. Do not commence site clearing operations until temporary erosion- and sedimentation-control measures are in place.
- D. Soil Stripping, Handling, and Stockpiling: Perform only when the soil is dry or slightly moist.

### **PART 2 - PRODUCTS**

#### **2.1 MATERIALS**

- A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving."
  - 1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

- B. Antirust Coating: Fast-curing, lead- and chromate-free, self-curing, universal modified-alkyd primer complying with surface-tolerant, anticorrosive metal primer.

## **PART 3 - EXECUTION**

### **3.1 PREPARATION**

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. 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. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations.

### **3.4 EXISTING UTILITIES**

- A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.
  - 1. Verify that utilities have been disconnected and capped before proceeding with site clearing.
- B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.



1. Owner will arrange to shut off indicated utilities when requested by Contractor.
- C. Locate, identify, and disconnect utilities indicated to be abandoned in place.
- D. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others, unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
  1. Notify Architect not less than two days in advance of proposed utility interruptions.

### **3.5 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 larger than 2 inches (50 mm) below exposed subgrade.
  3. Use only hand methods or air spade 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 (200 mm), and compact each layer to a density equal to adjacent original ground.

### **3.6 TOPSOIL STRIPPING**

- A. Remove sod and grass before stripping topsoil.
- B. Strip topsoil to depth of 6 inches (150 mm) 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 larger than 2 inches (50 mm) in diameter; trash, debris, weeds, roots, and other waste materials.
- C. Stockpile topsoil away from edge of excavations without intermixing with subsoil or other materials. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
  1. Limit height of topsoil stockpiles to 48 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.

- D. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.
- E. 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.
- F. 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.
- G. 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**

## **SECTION 321313 - CONCRETE PAVING**

### **PART 1 GENERAL**

#### **1.1 SECTION INCLUDES**

- A. Concrete pavement sidewalks, stair steps, integral curbs, gutters, and driveways.

#### **1.2 RELATED REQUIREMENTS**

- B. Section 033000 - Cast-in-Place Concrete.

#### **1.3 REFERENCE STANDARDS**

- A. Missouri Standard Specifications for Highway Construction (MSSHHC)
  - 1. Section 501, Concrete
  - 2. Section 608, Concrete Median, Median Strip, Sidewalk, Curb Ramps, Steps and Paved Approaches
  - 3. Section 609, Paved Drainage
- B. ACI 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete; 1991 (Reapproved 2009).
- C. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens; 2020.
- D. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete; 2020.
- E. ASTM C173/C173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method; 2016.

#### **1.4 SUBMITTALS**

- A. See Section 013000 – “Submittals”, for submittal procedures.
- B. Product Data: Provide data on joint filler, admixtures, curing compound, and mix designs.

## **PART 2 PRODUCTS**

### **2.1 FORM MATERIALS**

- A. Joint Filler: Preformed; non-extruding bituminous type (ASTM D1751).
  - 1. Thickness: 1/2 inch.

### **2.2 REINFORCEMENT**

- A. Reinforcing Steel: ASTM A615/A615M, Grade 60 (60,000 psi) yield strength; deformed billet steel bars; epoxy coated.
- B. Dowels: ASTM A615/A615M, Grade 60 - 60,000 psi yield strength; smooth steel bars; epoxy coated.

### **2.3 CONCRETE MATERIALS**

- A. Obtain cementitious materials from same source throughout.
- B. Concrete Materials: Provide in accordance with MSSHC Section 501.

### **2.4 ACCESSORIES**

- A. Slab Isolation Joint Filler: 1/2 inch thick, height equal to slab thickness, with removable top section that will form 1/2 inch deep sealant pocket after removal.
  - 1. Material: ASTM D1751, cellulose fiber.

### **2.5 CONCRETE MIX DESIGN**

- A. Mix Design shall conform MSSHC Section 501.3 for Pavement Concrete.
- B. Admixtures: Add acceptable admixtures as recommended in ACI 211.1 and at rates recommended by manufacturer.

### **2.6 MIXING**

- A. Transit Mixers: Comply with ASTM C94/C94M.

## **PART 3 EXECUTION**

### **3.1 EXAMINATION**

- A. Verify compacted subgrade is acceptable and ready to support paving and imposed loads.
- B. Verify gradients and elevations of base are correct.

### **3.2 SUBBASE**

- A. See Section 321123 for construction of base course for work of this Section.

### **3.3 PREPARATION**

- A. Moisten base to minimize absorption of water from fresh concrete.
- B. Coat surfaces of manhole and catch basin frames with oil to prevent bond with concrete pavement.

### **3.04 FORMING**

- A. Place and secure forms to correct location, dimension, profile, and gradient.
- B. Place joint filler vertical in position, in straight lines. Secure to formwork during concrete placement.

### **3.05 REINFORCEMENT**

- A. Place reinforcement as indicated.

### **3.06 COLD AND HOT WEATHER CONCRETING**

- A. Follow recommendations of ACI 305R when concreting during hot weather.
- B. Follow recommendations of ACI 306R when concreting during cold weather.
- C. Do not place concrete when base surface temperature is less than 40 degrees F, or surface is wet or frozen.

### **3.07 PLACING CONCRETE**

- A. Place concrete in accordance with Section 502 of MSSHC standards.

- B. Ensure reinforcement, inserts, embedded parts, formed joints are not disturbed during concrete placement.
- C. Place concrete continuously over the full width of the panel and between predetermined construction joints. Do not break or interrupt successive pours such that cold joints occur.

### **3.08 JOINTS**

- A. Align curb, gutter, and sidewalk joints.
- B. Provide joints as indicated on the drawings.

### **3.09 FINISHING**

- A. Sidewalk Paving: Light broom, texture perpendicular to direction of travel with troweled and radiused edge 1/4 inch radius.
- B. Curbs and Gutters: Light broom, texture parallel to pavement direction.
- C. Place curing compound on exposed concrete surfaces immediately after finishing. Apply in accordance with manufacturer's instructions.

### **3.10 TOLERANCES**

- A. Maximum Variation of Surface Flatness: 1/4 inch in 10 ft.
- B. Maximum Variation From True Position: 1/4 inch.

### **3.11 FIELD QUALITY CONTROL**

- A. Testing Agency: Contractor will engage a qualified testing and inspecting agency to sample materials, perform tests, and submit test reports during concrete placement.
- B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C172 shall be performed according to the following requirements:
  - 1. Testing Frequency: Obtain at least 1 composite sample for each 100 cy. yd. or 5,000 sq. ft. or fraction thereof of each concrete mix placed each day.
  - 2. Slump: ASTM C143; one test a 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 C231, 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 C1064; one test hourly when air temperature is 40 deg. F and below and when 80 deg. F and above, and one for each composite sample.

5. 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 concrete mix will be satisfactory if the 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 the Owner, 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. 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 Owner.
- F. Remove and replace concrete where test results indicate that it does not comply with specified requirements.
- G. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

### **3.12 PROTECTION**

- A. Immediately after placement, protect pavement from premature drying, excessive hot or cold temperatures, and mechanical injury.
- B. Do not permit vehicular traffic over pavement until 75 percent design strength of concrete has been achieved.

**END OF SECTION - 321313**

## **SECTION 329200 – LAWNS AND GRASSES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division Specification sections, and the Approved DNR Land Disturbance Permit, apply to the Work specified in this Section.

#### **1.2 DESCRIPTION OF WORK**

- A. Furnish all materials, labor, equipment and services necessary to perform all Work.
- B. Work included in this Section includes clearing of weeds, seed bed preparation, installation of erosion control fabric and seeding operations required for seeding of the areas shown on Drawings.

#### **1.3 SPECIFICATIONS AND STANDARDS**

- A. U.S. Department of Agriculture: SRA 156 U.S. Department of Agriculture, Rules and Regulations under the Federal Seed Act.
- B. American Joint Committee on Horticultural Nomenclature Standard: 1942 Edition Standardized Plant Names.

### **PART 2 - PRODUCTS**

#### **2.1 SEED**

- A. All seed shall be furnished in sealed, standard containers, unless otherwise approved. Seed which has become wet, moldy, or otherwise damaged will not be acceptable.
- B. Each container of seed shall be fully labeled in accordance with the Federal Seed Act and seed certifications shall be signed and made part of seed invoices.
- C. Seed shall be Fescue, 97 percent pure live seed
- D. Invoices and tags for seed shall show type furnished. Upon acceptance of the seeded areas, a final check of total quantities of seed used will be made against total area seeded and if minimum rates of application or specified quantities have not been met, the Architect will require distribution of additional quantities of these materials to make up minimum application specified.



## **2.2 FERTILIZER**

- A. Fertilizer shall be uniform in composition, free-flowing, suitable for application with approved equipment and delivered to the site unopened in original containers each bearing the manufacturer's guaranteed analysis and in conformity with state fertilizer laws. Fertilizer shall contain the following minimum percentage of plant food by weight.
  - 1. 12 percent available nitrogen
  - 2. 12 percent available phosphoric acid
  - 3. 12 percent available potash
- B. Fertilizer application rates shall be 600 pounds per acre with a minimum of \_\_\_\_\_ lbs applied.
- C. Invoices for fertilizer shall show grade furnished. Upon acceptance of the seeded areas, a final check of total quantities of fertilizer used will be made against total area seeded and if minimum rates of application or specified quantities have not been met, the Architect will require distribution of additional quantities of these materials to make up minimum application specified.

## **2.3 EROSION CONTROL FABRIC**

- A. Fabric shall be "Soil Saver" as is distributed by Jim Walls Company in Dallas, Texas (214) 239-8577; or "Curlex Blankets" as is distributed by Americal Excelsior Company in North Kansas City, Missouri (816) 842-3034; or approved equal.

## **2.4 STAPLES**

- A. Staples shall be a No. 11 gauge steel wire formed into a "U" shape, 6 inches long.

## **PART 3 - EXECUTION**

### **3.1 GROUND PREPARATION**

- A. General: the ground areas are to be seeded and fertilized as indicated on the Drawings and/or as specified herein. Equipment necessary for the proper preparation of the ground surface and for handling and placing all required materials shall be on hand, in good condition and shall be approved before the Work is started.
- B. Clearing: Prior to tillage, seeding or other specified operations, all vegetation which might interfere with the indicated treatment of the areas shall be mowed, grubbed, raked and the debris removed from the site. Prior to or during grading and tillage operations, the ground surface shall be cleared of materials which might hinder final operations. Areas which have been disturbed shall be finish graded and/or developed as indicated on the Drawings or as specified.
- C. Tillage: After the areas required to be seeded have been brought to the finish grades as specified, they shall be thoroughly tilled to a depth of at least 6 inches by plowing, disking, harrowing or

other approved methods until the condition of the soil is acceptable to the Architect. Work shall be performed only during period when beneficial results are likely to be obtained. When conditions are such by reason of drought, excessive moisture, or other factors that satisfactory results are not likely to be obtained, Work shall be stopped. Work shall be resumed only when desired results are likely to be obtained.

- D. Leveling: Any undulations or irregularities in the surface resulting from tillage, fertilizing or other operations shall be leveled with a float drag before seeding operations are begun.
- E. Fertilizing: Fertilizer shall be distributed uniformly at the rate previously specified per 1,000 square feet over the areas to be seeded and shall be incorporated into the soil to a depth of at least 3 to 4 inches by disking, harrowing or other approved methods. The incorporation of fertilizer may be a part of the tillage operation hereinbefore specified. Distribution by means of an approved seed drill equipped to sow seed and distribute fertilizer at the same time will not be accepted. Fertilizer shall be incorporated into the soil a minimum of 10 days before seed is planted.
- F. Inspection: A minimum of 48 hours prior notice must be given to the Construction Administrator before fertilizing may commence.
- G. Planting Time: All seeding Work shall be done between the dates of April 1 to May 15 for spring planting and from August 15 to October 15 for fall planting except as otherwise directed in writing by the Construction Administrator.
- H. Planting Condition: No planting shall be done until a permanent source of water is available at the site for use by the Owner.

### **3.2 SEEDING**

- A. General: Prior to seeding, any previously prepared seedbed areas compacted or damaged by interim rains, traffic, or other cause shall be reworked to restore the ground condition previously specified. Seed shall be planted by drill seeding.
- B. Drill Seeding: Seed shall be uniformly drilled to an average depth of  $\frac{1}{2}$  inch and at the rate of 8 pounds per 1,000 square feet using equipment having drills not more than 6  $\frac{1}{2}$  inches apart. Row markers shall be used with the drill seeder.
- C. Rolling: Immediately after seeding, except for slopes 3 horizontal to 1 vertical and greater, the entire area shall be firmed with a roller not exceeding 90 pounds for each foot of roller width. Do not roll areas seeded with seed drills equipped with rollers.
- D. Inspection: A minimum of 48 hours prior notice must be given to the Construction Administrator before seeding may commence.

### **3.3 INSTALLATION OF EROSION CONTROL FABRIC**

- A. Fabric shall be rolled out in place. Fabric shall be applied without stretching and shall lie smoothly but loosely on the soil surface. The Contractor shall refer to the Drawings for details of fabric fastening.
- B. Application of the erosion control fabric shall occur the same day that the seeding of an area has taken place.
- C. Fabric shall completely cover all areas which are shown on the Drawings to be protected from erosion. After fabric installation, the entire area shall be rolled with a smooth roller weighing between 200 to 250 pounds. After rolling, the fabric shall be in intimate contact with the soil surface at all points. Any clods, etc., which hold the fabric off the ground should be removed. The fabric shall be forced down into any depressions and held there with a staple.

### **3.4 MAINTENANCE**

- A. General: The project areas shall be kept clean at all times and care shall be taken that use of the premises shall not be unduly hampered by Work herein specified. The intent of this Section is to ensure a healthy, well-established turf, and prevent soil erosion in compliance with the Land Disturbance Permit issued by the Missouri Department of Natural Resources.
- B. Responsibility: The Owner shall be responsible for maintenance of all seeded areas upon completion of seeding and general acceptance by the Construction Administrator.
- C. Damage: Damage to seeded areas during the project shall be repaired by the persons responsible for causing such damage.

### **3.5 GENERAL ACCEPTANCE**

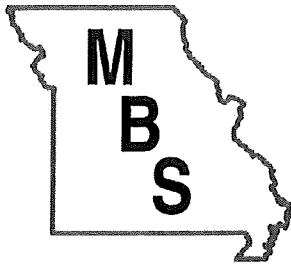
- A. The Construction Administrator shall make an inspection of the seeded areas upon completion of seeding. Seeded areas shall be considered acceptable if the specified quantities of fertilizer & seed have been properly applied.

### **3.6 GUARANTEE**

- A. The Contractor is responsible for the proper application of the fertilizer & seeding. Watering, weeding, re-seeding, and mowing will be the responsibility of the Owner after proper application of the seed.

**END OF SECTION 329200**

## Exhibit A



# MISSOURI BUILDERS SERVICE, INC.

ROOFING • SHEET METAL

3807 ROUTE CC • P.O. BOX 104205 • JEFFERSON CITY, MO 65110-4205

PHONE 573.636.7733 FAX 573.636.7836

## *Roofing Installers Warranty*

*Whereas* Missouri Builders Service, Inc of Jefferson City, herein called the "Roofing Installer," has performed roofing and associated work ("work") on the following project;

**Owner: State of Missouri**

**Project Name: R1801-01 Replace Roof- Administration Building**

**Address: General Headquarters Missouri State Highway Patrol**

**1510 East Elm Street, Jefferson City, Missouri**

**Area of Work: TPO Membrane Roofing - 24,488 SF**

**Completion Date: December 4, 2018**

**Warranty Period: Two Year**

**Expiration Date: December 4, 2020**

*And Whereas* Roofing Installer has contracted (either directly with Owner or indirectly as a subcontract) to warranty said work against leaks and faulty or defective materials and workmanship for designated Warranty Period.

*Now Therefore* Roofing Installer hereby warrants, subject to terms and conditions herein set forth, that during Warranty Period he will, at his own cost and expense, make or cause to be made such repairs to or replacements of said work as are necessary to correct faulty and defective work and as are necessary to maintain said work in a watertight condition.

This Warranty is made subject to the following terms and conditions:

Specifically excluded from this Warranty are damages to work and other parts of the building, and to building contents, caused by; lightning; peak gust wind speed exceeding 72 mph; fire; failure of roof system substrate, including cracking, settlement, excessive deflection, deterioration, and decomposition; faulty construction of parapet walls, copings, chimneys, skylights, vents, equipment supports, and other edge conditions and penetrations of the work; vapor condensation on bottom of roof; and activity on roofing by others, including construction contractors, maintenance personnel, other persons, and animals, whether authorized or unauthorized by Owner.

When work has been damaged by any of foregoing causes, Warranty shall be null and void until such damage has been repaired by Roofing Installer and until cost and expense thereof have been paid by Owner or by another responsible party so designated.

Roofing installer is responsible for damage to work covered by this Warranty but is not liable for consequential damages to building or building contents resulting from leaks or faults or defects of work.

During Warranty Period, if Owner allows alteration of work by anyone other than Roofing Installer, including cutting, patching, and maintenance in connection with penetration, attachment of other work, and positioning of anything on roof, this Warranty shall become null and void on date of said alterations, but only to the extent said alterations affect work covered by this Warranty. If Owner engages Roofing Installer to perform said alterations, Warranty shall not become null and void unless showing reasonable cause for claim, that said alterations would likely damage or deteriorate work, thereby reasonably justifying a limitation or termination of this Warranty.

During Warranty Period, if original use of roof is changed and it becomes used for, but was not originally specified for, a promenade, work deck, spray-cooled surface, flooded basin, or other use or service more severe than originally specified, this Warranty shall become null and void on date of said change, but only to the extent said change affects work covered by this Warranty.

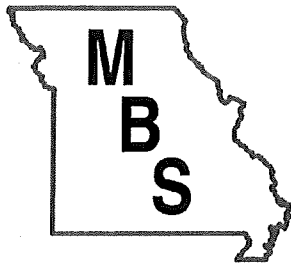
Owner shall promptly notify Roofing Installer of observed, known, or suspected leaks, defects, or deterioration and shall afford reasonable opportunity for Roofing Installer to inspect work and to examine evidence of such leaks, defects, or deterioration.

This Warranty is recognized to be the only warranty of Roofing Installer on said work and shall not operate to restrict or cut off owner from other remedies and resources lawfully available to Owner in cases of roofing failure. Specifically, this Warranty shall not operate to relieve Roofing Installer of responsibility for performance of original work according to requirements of the Contract Documents, regardless of whether Contract was a contract directly with Owner or a subcontract with Owner's General Contractor.

*In Witness Whereof*, this instrument has been duly executed this 4th day of December, 2018

Missouri Builders Service, Inc.

Tom M. Caspari. President



# MISSOURI BUILDERS SERVICE, INC.

ROOFING • SHEET METAL

3807 ROUTE CC • P.O. BOX 104205 • JEFFERSON CITY, MO 65110-4205

PHONE 573.636.7733 FAX 573.636.7836

## *Sheet Metal Installers Warranty*

Whereas Missouri Builders Service, Inc of Jefferson City, herein called the Sheet Metal Installer," has performed sheet metal and associated work ("work") on the following project;

**Owner: State of Missouri**

**Project Name: R1801-01 Replace Roof- Administration Building**

**Address: General Headquarters Missouri State Highway Patrol**

**1510 East Elm St., Jefferson City, Missouri**

**Area of Work: Sheet Metal Flashing & Trim**

**Completion Date: December 4, 2018**

**Warranty Period: Five Years**

**Expiration Date: December 4, 2023**

And Whereas Sheet Metal Installer has contracted (either directly with Owner or indirectly as a subcontract) to warranty said work against leaks and faulty or defective materials and workmanship for designated Warranty Period.

Now Therefore Sheet Metal Installer hereby warrants, subject to terms and conditions herein set forth, that during Warranty Period he will, at his own cost and expense, make or cause to be made such repairs to or replacements of said work as are necessary to correct faulty and defective work and as are necessary to maintain said work in a watertight condition.

This Warranty is made subject to the following terms and conditions:

Specifically excluded from this Warranty are damages to work and other parts of the building, and to building contents, caused by; lightning; peak gust wind speed exceeding 72 mph; fire; failure of roof system substrate, including cracking, settlement, excessive deflection, deterioration, and decomposition; faulty construction of parapet walls, copings, chimneys, skylights, vents, equipment supports, and other edge conditions and penetrations of the work; vapor condensation on bottom of roof; and activity on roofing by others, including construction contractors, maintenance personnel, other persons, and animals, whether authorized or unauthorized by Owner.

When work has been damaged by any of foregoing causes, Warranty shall be null and void until such damage has been repaired by Sheet Metal Installer and until cost and expense thereof have been paid by Owner or by another responsible party so designated. Sheet Metal Installer is responsible for damage to work covered by this Warranty but is not liable for consequential damages to building or building contents resulting from leaks or faults or defects of work.

During Warranty Period, if Owner allows alteration of work by anyone other than Sheet Metal Installer, including cutting, patching, and maintenance in connection with penetration, attachment of other work, and positioning of anything on roof, this Warranty shall become null and void on date of said alterations, but only to the extent said alterations affect work covered by this Warranty. If Owner engages Sheet Metal Installer to perform said alterations, Warranty shall not become null and void unless showing reasonable cause for claim, that said alterations would likely damage or deteriorate work, thereby reasonably justifying a limitation or termination of this Warranty. During Warranty Period, if original use of roof is changed and it becomes used for, but was not originally specified for, a promenade, work deck, spray-cooled surface, flooded basin, or other use or service more severe than originally specified, this Warranty shall become null and void on date of said change, but only to the extent said change affects work covered by this Warranty.

Owner shall promptly notify Sheet Metal Installer of observed, known, or suspected leaks, defects, or deterioration and shall afford reasonable opportunity for Sheet Metal Installer to inspect work and to examine evidence of such leaks, defects, or deterioration.

This Warranty is recognized to be the only warranty of Sheet Metal Installer on said work and shall not operate to restrict or cut off owner from other remedies and resources lawfully available to Owner in cases of roofing failure. Specifically, this Warranty shall not operate to relieve Sheet Metal Installer of responsibility for performance of original work according to requirements of the Contract Documents, regardless of whether Contract was a contract directly with Owner or a subcontract with Owner's General Contractor.

*In Witness Whereof*, this instrument has been duly executed this 4th day of December, 2018

Missouri Builders Service, Inc.

Tom M. Caspari, President

CARLISLE

# GOLDEN SEAL Total Roofing System WARRANTY

SERIAL NO. 10174212

919

DATE OF ISSUE: December 20, 2018

BUILDING OWNER: STATE OF MISSOURI

NAME OF BUILDING: MSHP GENERAL HEADQUARTERS COMPLEX- ADMINISTRATION BUILDING

BUILDING ADDRESS: 1510 EAST ELEM STREET, JEFFERSON CITY, MO

DATE OF COMPLETION OF THE CARLISLE TOTAL ROOFING SYSTEM: 12/04/2018

DATE OF ACCEPTANCE BY CARLISLE: 12/20/2018

(EB Warranty)

AB#1258790

Carlisle Roofing Systems, Inc., (Carlisle) warrants to the Building Owner (**Owner**) of the above described building, that; subject to the terms, conditions, and limitations stated in this warranty, Carlisle will repair any leak in the Carlisle Golden Seal™ Total Roofing System (**Carlisle Total Roofing System**) installed by a Carlisle Authorized Roofing applicator for a period of **20** years commencing with the date of Carlisle's acceptance of the Carlisle Total Roofing System installation. However, in no event shall Carlisle's obligations extend beyond **20.5** years subsequent to the date of substantial completion of the Carlisle Total Roofing System. See below for exact date of warranty expiration.

The Carlisle Total Roofing System is defined as the following Carlisle brand materials: Membrane, Flashings, Adhesives and Sealants, Insulation, Cover Boards, Fasteners, Fastener Plates, Fastening Bars, Insulation Adhesives, and any other Carlisle brand products utilized in this installation.

## TERMS, CONDITIONS, LIMITATIONS

- Owner shall provide Carlisle with written notice via letter, fax or email within thirty (30) days of the discovery of any leak in the Carlisle Total Roofing System. Owner should send written notice of a leak to Carlisle's Warranty Services Department at the address set forth at the bottom of this warranty. By so notifying Carlisle, the Owner authorizes Carlisle or its designee to investigate the cause of the leak. Should the investigation reveal the cause of the leak to be outside the scope of this Warranty, investigation and repair costs for this service shall be paid by the Owner.
- If, upon inspection, Carlisle determines that the leak is caused by a defect in the Carlisle Total Roofing System's materials, or workmanship of the Carlisle Authorized Roofing Applicator in installing the same, Owner's remedies and Carlisle's liability shall be limited to Carlisle's repair of the leak.
- This warranty shall not be applicable if, upon Carlisle's inspection, Carlisle determines that any of the following has occurred:
  - The Carlisle Total Roofing System is damaged by natural disasters, including, but not limited to, lightning, fire, insect infestations, earthquake, tornado, hail, hurricanes, and winds of (3 second) peak gust speeds of seventy-two mph or higher measured at 10 meters above ground; or
  - Loss of integrity of the building envelope and, or structure including, but not limited to partial or complete loss of roof decking, wall siding, windows, doors or other envelope components or from roof damage by wind-blown objects, or;
  - The Carlisle Total Roofing System is damaged by any intentional or negligent acts, accidents, misuse, abuse, vandalism, civil disobedience, or the like.
  - Deterioration or failure of building components, including, but not limited to, the roof substrate, walls, mortar, HVAC units, non-Carlisle brand metal work, etc., occurs and causes a leak, or otherwise damages the Carlisle Total Roofing System; or
  - Acids, oils, harmful chemicals and the like come in contact with the Carlisle Total Roofing System and cause a leak, or otherwise damage the Carlisle Total Roofing System.
  - The Carlisle Total Roofing System encounters leaks or is otherwise damaged by condensation resulting from any condition within the building that may generate moisture.
- This Warranty shall be null and void if any of the following shall occur:
  - If, after installation of the Carlisle Total Roofing System by a Carlisle Authorized Roofing Applicator there are any alterations or repairs made on or through the roof or objects such as, but not limited to, structures, fixtures, solar panels, wind turbines, roof gardens or utilities are placed upon or attached to the roof without first obtaining written authorization from Carlisle; or
  - Failure by the Owner to use reasonable care in maintaining the roof, said maintenance to include, but not be limited to, those items listed on Carlisle's Care & Maintenance Information sheet which accompanies this Warranty.
- Only Carlisle brand insulation products are covered by this warranty. Carlisle specifically disclaims liability, under any theory of law, for damages sustained by or caused by non-Carlisle brand insulation products.
- During the term of this Warranty, Carlisle shall have free access to the roof during regular business hours.
- Carlisle shall have no obligation under this Warranty while any bills for installation, supplies, service, and warranty charges have not been paid in full to the Carlisle Authorized Roofing Applicator, Carlisle, or material suppliers.
- Carlisle's failure at any time to enforce any of the terms or conditions stated herein shall not be construed to be a waiver of such provision.
- Carlisle shall not be responsible for the cleanliness or discoloration of Carlisle Total Roofing System caused by environmental conditions including, but not limited to, dirt, pollutants or biological agents.
- Carlisle shall have no liability under any theory of law for any claims, repairs, restoration, or other damages including, but not limited to, consequential or incidental damages relating, directly or indirectly, to the presence of any irritants, contaminants, vapors, fumes, molds, fungi, bacteria, spores, mycotoxins, or the like in the building or in the air, land, or water serving the building.
- This warranty shall be transferable upon a change in ownership of the building when the owner has completed certain procedures including a transfer fee and an inspection of the Roofing System by a Carlisle representative.

CARLISLE DOES NOT WARRANT PRODUCTS UTILIZED IN THIS INSTALLATION WHICH IT HAS NOT FURNISHED; AND SPECIFICALLY DISCLAIMS LIABILITY, UNDER ANY THEORY OF LAW, ARISING OUT OF THE INSTALLATION AND PERFORMANCE OF, OR DAMAGES SUSTAINED BY OR CAUSED BY, PRODUCTS NOT FURNISHED BY CARLISLE OR THE PRIOR EXISTING ROOFING MATERIAL OVER WHICH THE CARLISLE ROOFING SYSTEM HAS BEEN INSTALLED.

THE REMEDIES STATED HEREIN ARE THE SOLE AND EXCLUSIVE REMEDIES FOR FAILURE OF THE CARLISLE TOTAL ROOFING SYSTEM OR ITS COMPONENTS. THERE ARE NO WARRANTIES EITHER EXPRESSED OR IMPLIED, INCLUDING THE IMPLIED WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE AND MERCHANTABILITY, WHICH EXTEND BEYOND THE FACE HEREOF. CARLISLE SHALL NOT BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR OTHER DAMAGES INCLUDING, BUT NOT LIMITED TO, LOSS OF PROFITS OR DAMAGE TO THE BUILDING OR ITS CONTENTS UNDER ANY THEORY OF LAW.

BY: Mark J. Long

AUTHORIZED SIGNATURE

TITLE: Director, Technical and Warranty Services

This Warranty Expires: December 19, 2038



## DYNACLAD® KYNAR 500® COATING 20 Year Limited Warranty

Dimensional Metals, Inc. (DMI) warrants for a period of twenty (20) years after Customer's shipment of painted products that Dimensional Metal's standard color, Medium Gloss DynaClad® coil coatings (Coatings) when applied on Galvalume, HDG-90 steel and aluminum substrate will not:

- A. Peel, flake or otherwise lose adhesion to an extent that is apparent on ordinary outdoor visual observation.
- B. Change color more than 5 Delta E Units when measured per ASTM D-2244 on clean surface.
- C. Chalk more than a number eight (8) rating when measured per ASTM D-4214.

### TERMS AND CONDITIONS

1. It is acknowledged that fading or color change may not be uniform if the surfaces are not equally exposed to the sun and elements. DMI recommends that there be a systematic fresh water rinse maintenance program in effect in areas of high salt concentration (such as adjacent to the seashore and/or industrial atmospheres) so as to prevent the accumulation of concentrated mineral deposits.
2. This Limited Warranty covers DMI Coatings exposed to normal atmospheric conditions and specifically excludes corrosive or aggressive atmospheres including direct salt spray, contact with animal or animal waste. This Limited Warranty shall not apply where coating failure is the result of physical damage resulting from fabrication or embossing operations, corrosion due to cut edge exposure, salt spray, acts of God, vandalism, any negligent acts of the Customer including, but not limited to, improper packaging, storage, shipping, or, installation which prohibit proper drainage of standing water or other such occurrences beyond DMI's control.
3. DMI's liability and the Customer's exclusive remedy for any breach of this Limited Warranty or failure of the Coatings is strictly limited to the direct cost of refinishing or replacing the failed coated metal. Refinishing of the failed coated metal shall be performed by using standard finishing practices and materials. DMI will, in all instances, be the sole judge as to whether refinishing or replacement of the failed areas is required to fulfill its obligation under this Limited Warranty and reserves the right to approve and negotiate the contract.
4. This Limited Warranty shall not be extended by the refinishing or replacement of the coated material, but the remaining warranty period shall continue in effect and be applicable to the refinished or replaced areas under the terms and conditions of the Limited Warranty.
5. Claims under this Limited Warranty must be presented in writing during the warranty period and within sixty (60) days after Customer becomes aware that any warranted condition has occurred. Time is of the essence and failure to give notice within the specified time shall discharge DMI from any obligations under this Limited Warranty. DMI must be given a reasonable opportunity to an on-site inspection to determine the cause and the corrective action to be taken if it is determined to be a Coating failure.
6. THIS LIMITED WARRANTY IS GIVEN AS THE EXCLUSIVE WARRANTY AND REMEDY, AND DMI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, DMI SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES. THE CUSTOMER'S EXCLUSIVE REMEDY SHALL BE THAT SET FORTH IN PARAGRAPH 3 FOR ANY CLAIM OF LIABILITY RELATING TO THE COATINGS UNDER NEGLIGENCE, STRICT LIABILITY, BREACH OF WARRANTY, OR ANY OTHER LEGAL THEORY.
7. This Limited Warranty is extended to Customer alone, is nontransferable and non-assignable, and may not be modified or enlarged in its scope by any representative, salesman, agent, or other employee of DMI. Customer shall not permit anyone to claim or imply that this Limited Warranty extends to anyone other than Customer. This condition is a material term of this Limited Warranty and its violation by Customer or its agents or representatives shall release DMI from its obligations hereunder.
8. This Limited Warranty shall be governed by and interpreted in accordance with the laws of the State of Ohio. Jurisdiction and venue for any dispute concerning the roof or this Limited Warranty are fixed in Franklin County, Ohio.

### R1801-01 Replace Roofs - Administration Building

Project Name

1510 East Elm Street

Address

Jefferson City MO 65101

City State Zip

DMI Flat Sheets in DynaClad 24ga White  
Material Description

### Missouri Builders Service, Inc.

Sold To

P.O. Box 104205

Address

Jefferson City MO 65110

City State Zip

18005509

Invoice/ (Order Number)

12/04/18

Effective Date

Dimensional Metals, Inc.

58 Kiema Drive North - Reynoldsburg, OH 43068 - (740) 927-3633

Signature

Title

Date





## GALVALUME SHEET 20 YEAR-6 MONTH LIMITED WARRANTY

### EXCLUSIVE WARRANTY

Dimensional Metals, Inc. 58 Klema Drive North, Reynoldsburg, Oh 43068 ("seller") hereby provides the LIMITED WARRANTY to: Missouri Builders Service, Inc. RE: R1801-01 Replace Roofs - Administration Building - 12/04/18 ("Buyer"). Dimensional Metals, Inc. Warrants that, subject to the following provisions, Seller's hot dipped aluminum-zinc alloy-coated Galvalume sheet steel sold for use as steel building, roofing and siding panels, if erected within the Continental United States, WILL NOT rupture, fail structurally, or perforate within a period of 20 years and 6 months after shipment from our facility due to exposure to normal atmospheric conditions.

### EXCLUDED ATMOSPHERIC CONDITIONS

This limited warranty DOES NOT APPLY to sheets exposed at any time to corrosive or aggressive atmospheric conditions, including but not limited to:

1. Areas subject to salt-water marine atmospheres or to constant spraying of either salt or fresh water.
2. Areas subject to fallout or exposure to corrosive chemicals, fumes, ash, cement dust or animal waste.
3. Areas subject to water run-off from lead or copper flashings or areas in metallic contact with lead or copper.
4. Conditions/circumstances where corrosive fumes or condensates are generated or released inside the building.

### OTHER EXCLUDED SITUATIONS

This warranty DOES NOT APPLY in the event of:

1. Bends less than 2T for sheet thickness 0.030" and thinner and less than 4T for sheet thickness 0.031" and thicker.
2. Slopes of the roof or sections of the roof flatter than 1/4:12.
3. Mechanical, chemical, or other damage sustained during shipment, storage, forming, fabrication, or during or after erection.
4. Forming which incorporates severe reverse bending or which subjects coating to alternate compression and tension.
5. Failure to provide free drainage of water, including internal condensation, from overlaps and all other surfaces of the sheets or panels.
6. Failure to remove debris from overlaps and all other surfaces of the sheets or panels.
7. Damage caused to the metallic coating by improper roll forming, scouring or cleaning procedures.
8. Deterioration of the panels caused by contact with green or wet lumber or wet storage stain caused by water damage or condensation.
9. Presence of damp insulation or other corrosive materials in contact with or close proximity to the panel.
10. This warranty does not apply in the event of deterioration to the panels caused directly or indirectly by panel contact with fasteners. Selection of suitable long-lasting fasteners to be used with Galvalume roofing and siding panels rests solely with the Buyer.

### EXCLUSIVE REMEDIES

Buyer's exclusive remedy and Seller's sole liability for breach of this limited warranty shall be limited exclusively to the cost of either repairing nonconforming panels, or at Seller's sole option, of furnishing FOB buyer's plant sufficient sheet product to enable Buyer to fabricate replacement panels for the nonconforming panels.

### LIMITATION OF DAMAGES

THE LIABILITY OF THE SELLER SHALL NOT EXTEND TO PERSONAL INJURY, PROPERTY DAMAGE, LOSS OF PROFIT, DELAY OR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM THE FAILURE OF ANY SHEET TO CONFORM WITH THE PROVISIONS OF THIS LIMITED WARRANTY.

### OTHER WARRANTIES, INCLUDING MERCHANTABILITY

THERE ARE NO WARRANTIES, PROMISES OR AFFIRMATIONS OF FACT, INCLUDING WARRANTIES OF MERCHANTABILITY AND OF FITNESS FOR A PARTICULAR PURPOSE OTHER THAN THOSE EXPRESSLY SET FORTH HEREIN. THE CONDITIONS OF LIABILITY, RIGHTS, OBLIGATIONS AND REMEDIES OF THE PARTIES RELATING TO CLAIMS ARISING FROM ANY NONCONFORMING SHEET SHALL BE GOVERNED EXCLUSIVELY BY THE TERMS SET FORTH HEREIN.

### INSPECTIONS AND NOTICE OF CLAIM

Buyer shall exercise diligence in inspection of material as received from Seller prior to utilization so as to mitigate expense involved in repairing, repainting, or replacing nonconforming sheets. Claims for any breach of warranty must be made within the period of this limited warranty and within 30 days after Buyer discovered the nonconforming sheet, and Buyer must give Seller a reasonable opportunity to inspect the material.

### DUTIES OF BUYER IN PRESENTING CLAIMS

As a condition precedent to Seller's liability hereunder, Buyer must present with his claim such records so to enable Seller and the date of installation in the form of building panels for the claimed nonconforming sheet. Buyer shall also present such evidence that establishes any claimed nonconformance was due to a breach of the limited warranty stated herein.

### TRANSFERS REPRESENTATIONS AND ASSIGNMENTS

UNLESS EXPRESSLY AGREED IN WRITING BY AND BETWEEN BUYER AND SELLER, THIS LIMITED WARRANTY IS EXTENDED TO BUYER AS THE ORIGINAL PURCHASER FROM SELLER AND IS NON-TRANSFERABLE AND BY ANY PURPORTED TRANSFER OR ASSIGNMENT, NOR SHALL ANY RIGHT AGAINST SELLER SURVIVE ANY TRANSFER OR ASSIGNMENT. BUYER OR ITS AGENTS OR REPRESENTATIVES SHALL NOT CLAIM, REPRESENT OR IMPLY NOR PERMIT ITS CUSTOMERS, DISTRIBUTORS, APPLICATORS, OR CONTRACTORS TO CLAIM, REPRESENT OR IMPLY THAT THIS LIMITED WARRANTY EXTENDS OR IS AVAILABLE TO PARTIES OTHER THAN THE PARTY TO THIS WARRANTY. THIS CONDITION SHALL CONSTITUTE A MATERIAL TERM OF THIS LIMITED WARRANTY AND ITS VIOLATION BY BUYER SHALL EXCUSE SELLER FROM ITS OBLIGATIONS HEREUNDER.

### WAIVER OR MODIFICATIONS OF SELLER'S RIGHTS

No terms or conditions, other than those stated herein, and no agreement or understanding, oral or written, and no course of conduct or performance, in any way purporting to modify this limited warranty or to waive Seller's rights hereunder, shall be binding on Seller unless the same be clearly set forth in a writing that expressly refers to this limited warranty and expressly refers to having such effect upon this limited warranty is signed by the authorized representative of Seller.

### TERMINATION

Seller reserves the right to terminate this limited warranty, except with respect to orders, which it has already accepted, upon the giving of written notice thereof.

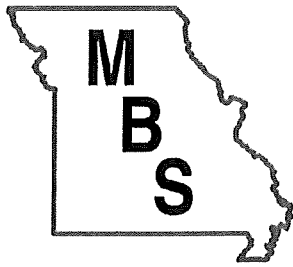
### GOVERNING LAW

The substantive law of the State of Ohio shall of exclusively govern the rights and duties of the parties under this agreement.

### ENTIRE AGREEMENT

The provisions set forth herein are in lieu of and expressly supersede any other provisions irrespective of where contained. All proposals, negotiations and representations, if any, made prior to or with reference hereto are merged herein.

  
Signature Title Date  
Dimensional Metals, Inc. 12/13/18



# MISSOURI BUILDERS SERVICE, INC.

ROOFING • SHEET METAL

3807 ROUTE CC • P.O. BOX 104205 • JEFFERSON CITY, MO 65110-4205

PHONE 573.636.7733 FAX 573.636.7836

## *Roofing Installers Warranty*

*Whereas* Missouri Builders Service, Inc of Jefferson City, herein called the "Roofing Installer," has performed roofing and associated work ("work") on the following project;

**Owner: State of Missouri**

**Project Name: R1801-01 Replace Roof- Academy Dormitory**

**Address: General Headquarters Missouri State Highway Patrol**

**1510 East Elm Street, Jefferson City, Missouri**

**Area of Work: TPO Membrane Roofing - 24,488 SF**

**Completion Date: December 4, 2018**

**Warranty Period: Two Year**

**Expiration Date: December 4, 2020**

*And Whereas* Roofing Installer has contracted (either directly with Owner or indirectly as a subcontract) to warranty said work against leaks and faulty or defective materials and workmanship for designated Warranty Period.

*Now Therefore* Roofing Installer hereby warrants, subject to terms and conditions herein set forth, that during Warranty Period he will, at his own cost and expense, make or cause to be made such repairs to or replacements of said work as are necessary to correct faulty and defective work and as are necessary to maintain said work in a watertight condition.

This Warranty is made subject to the following terms and conditions:

Specifically excluded from this Warranty are damages to work and other parts of the building, and to building contents, caused by; lightning; peak gust wind speed exceeding 72 mph; fire; failure of roof system substrate, including cracking, settlement, excessive deflection, deterioration, and decomposition; faulty construction of parapet walls, copings, chimneys, skylights, vents, equipment supports, and other edge conditions and penetrations of the work; vapor condensation on bottom of roof; and activity on roofing by others, including construction contractors, maintenance personnel, other persons, and animals, whether authorized or unauthorized by Owner.

When work has been damaged by any of foregoing causes, Warranty shall be null and void until such damage has been repaired by Roofing Installer and until cost and expense thereof have been paid by Owner or by another responsible party so designated.

Roofing installer is responsible for damage to work covered by this Warranty but is not liable for consequential damages to building or building contents resulting from leaks or faults or defects of work.

During Warranty Period, if Owner allows alteration of work by anyone other than Roofing Installer, including cutting, patching, and maintenance in connection with penetration, attachment of other work, and positioning of anything on roof, this Warranty shall become null and void on date of said alterations, but only to the extent said alterations affect work covered by this Warranty. If Owner engages Roofing Installer to perform said alterations, Warranty shall not become null and void unless showing reasonable cause for claim, that said alterations would likely damage or deteriorate work, thereby reasonably justifying a limitation or termination of this Warranty.

During Warranty Period, if original use of roof is changed and it becomes used for, but was not originally specified for, a promenade, work deck, spray-cooled surface, flooded basin, or other use or service more severe than originally specified, this Warranty shall become null and void on date of said change, but only to the extent said change affects work covered by this Warranty.

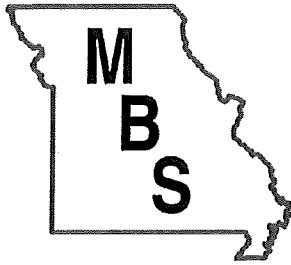
Owner shall promptly notify Roofing Installer of observed, known, or suspected leaks, defects, or deterioration and shall afford reasonable opportunity for Roofing Installer to inspect work and to examine evidence of such leaks, defects, or deterioration.

This Warranty is recognized to be the only warranty of Roofing Installer on said work and shall not operate to restrict or cut off owner from other remedies and resources lawfully available to Owner in cases of roofing failure. Specifically, this Warranty shall not operate to relieve Roofing Installer of responsibility for performance of original work according to requirements of the Contract Documents, regardless of whether Contract was a contract directly with Owner or a subcontract with Owner's General Contractor.

*In Witness Whereof*, this instrument has been duly executed this 4th day of December, 2018

Missouri Builders Service, Inc.

Tom M. Caspari, President



# MISSOURI BUILDERS SERVICE, INC.

ROOFING • SHEET METAL

3807 ROUTE CC • P.O. BOX 104205 • JEFFERSON CITY, MO 65110-4205

PHONE 573.636.7733 FAX 573.636.7836

## *Sheet Metal Installers Warranty*

*Whereas* Missouri Builders Service, Inc. of Jefferson City, herein called the Sheet Metal Installer," has performed sheet metal and associated work ("work") on the following project;

**Owner: State of Missouri**

**Project Name: R1801-01 Replace Roof- Academy Dormitory**

**Address: General Headquarters Missouri State Highway Patrol**

**1510 East Elm St., Jefferson City, Missouri**

**Area of Work: Sheet Metal Flashing & Trim**

**Completion Date: December 4, 2018**

**Warranty Period: Five Years**

**Expiration Date: December 4, 2023**

*And Whereas* Sheet Metal Installer has contracted (either directly with Owner or indirectly as a subcontract) to warranty said work against leaks and faulty or defective materials and workmanship for designated Warranty Period.

*Now Therefore* Sheet Metal Installer hereby warrants, subject to terms and conditions herein set forth, that during Warranty Period he will, at his own cost and expense, make or cause to be made such repairs to or replacements of said work as are necessary to correct faulty and defective work and as are necessary to maintain said work in a watertight condition.

This Warranty is made subject to the following terms and conditions:

Specifically excluded from this Warranty are damages to work and other parts of the building, and to building contents, caused by; lightning; peak gust wind speed exceeding 72 mph; fire; failure of roof system substrate, including cracking, settlement, excessive deflection, deterioration, and decomposition; faulty construction of parapet walls, copings, chimneys, skylights, vents, equipment supports, and other edge conditions and penetrations of the work; vapor condensation on bottom of roof; and activity on roofing by others, including construction contractors, maintenance personnel, other persons, and animals, whether authorized or unauthorized by Owner.

When work has been damaged by any of foregoing causes, Warranty shall be null and void until such damage has been repaired by Sheet Metal Installer and until cost and expense thereof have been paid by Owner or by another responsible party so designated. Sheet Metal Installer is responsible for damage to work covered by this Warranty but is not liable for consequential damages to building or building contents resulting from leaks or faults or defects of work.

During Warranty Period, if Owner allows alteration of work by anyone other than Sheet Metal Installer, including cutting, patching, and maintenance in connection with penetration, attachment of other work, and positioning of anything on roof, this Warranty shall become null and void on date of said alterations, but only to the extent said alterations affect work covered by this Warranty. If Owner engages Sheet Metal Installer to perform said alterations, Warranty shall not become null and void unless showing reasonable cause for claim, that said alterations would likely damage or deteriorate work, thereby reasonably justifying a limitation or termination of this Warranty.

During Warranty Period, if original use of roof is changed and it becomes used for, but was not originally specified for, a promenade, work deck, spray-cooled surface, flooded basin, or other use or service more severe than originally specified, this Warranty shall become null and void on date of said change, but only to the extent said change affects work covered by this Warranty.

Owner shall promptly notify Sheet Metal Installer of observed, known, or suspected leaks, defects, or deterioration and shall afford reasonable opportunity for Sheet Metal Installer to inspect work and to examine evidence of such leaks, defects, or deterioration.

This Warranty is recognized to be the only warranty of Sheet Metal Installer on said work and shall not operate to restrict or cut off owner from other remedies and resources lawfully available to Owner in cases of roofing failure. Specifically, this Warranty shall not operate to relieve Sheet Metal Installer of responsibility for performance of original work according to requirements of the Contract Documents, regardless of whether Contract was a contract directly with Owner or a subcontract with Owner's General Contractor.

*In Witness Whereof*, this instrument has been duly executed this 4th day of December, 2018

Missouri Builders Service, Inc.

Tom M. Caspari. President

CARLISLE

# GOLDEN SEAL Total Roofing System Warranty

SERIAL NO. 10173369 REV.01

919

DATE OF ISSUE: December 05, 2018

BUILDING OWNER: STATE OF MISSOURI

NAME OF BUILDING: MSHP GENERAL HEADQUARTERS COMPLEX-ACADEMY DORMITORY

BUILDING ADDRESS: 1510 EAST ELM STREET, JEFFERSON CITY, MO

DATE OF COMPLETION OF THE CARLISLE TOTAL ROOFING SYSTEM: 12/04/2018

DATE OF ACCEPTANCE BY CARLISLE: 12/05/2018

(EB Warranty)

CMD1252028

Carlisle Roofing Systems, Inc., (Carlisle) warrants to the Building Owner (**Owner**) of the above described building, that; subject to the terms, conditions, and limitations stated in this warranty, Carlisle will repair any leak in the Carlisle Golden Seal™ Total Roofing System (**Carlisle Total Roofing System**) installed by a Carlisle Authorized Roofing applicator for a period of **20** years commencing with the date of Carlisle's acceptance of the Carlisle Total Roofing System installation. However, in no event shall Carlisle's obligations extend beyond **20.5** years subsequent to the date of substantial completion of the Carlisle Total Roofing System. See below for exact date of warranty expiration.

The Carlisle Total Roofing System is defined as the following Carlisle brand materials: Membrane, Flashings, Adhesives and Sealants, Insulation, Cover Boards, Fasteners, Fastener Plates, Fastening Bars, Insulation Adhesives, and any other Carlisle brand products utilized in this installation.

## TERMS, CONDITIONS, LIMITATIONS

- Owner shall provide Carlisle with written notice via letter, fax or email within thirty (30) days of the discovery of any leak in the Carlisle Total Roofing System. Owner should send written notice of a leak to Carlisle's Warranty Services Department at the address set forth at the bottom of this warranty. By so notifying Carlisle, the Owner authorizes Carlisle or its designee to investigate the cause of the leak. Should the investigation reveal the cause of the leak to be outside the scope of this Warranty, investigation and repair costs for this service shall be paid by the Owner.
- If, upon inspection, Carlisle determines that the leak is caused by a defect in the Carlisle Total Roofing System's materials, or workmanship of the Carlisle Authorized Roofing Applicator in installing the same, Owner's remedies and Carlisle's liability shall be limited to Carlisle's repair of the leak.
- This warranty shall not be applicable if, upon Carlisle's inspection, Carlisle determines that any of the following has occurred:
  - The Carlisle Total Roofing System is damaged by natural disasters, including, but not limited to, lightning, fire, insect infestations, earthquake, tornado, hail, hurricanes, and winds of (3 second) peak gust speeds of seventy-two mph or higher measured at 10 meters above ground; or
  - Loss of integrity of the building envelope and, or structure including, but not limited to partial or complete loss of roof decking, wall siding, windows, doors or other envelope components or from roof damage by wind-blown objects, or;
  - The Carlisle Total Roofing System is damaged by any intentional or negligent acts, accidents, misuse, abuse, vandalism, civil disobedience, or the like.
  - Deterioration or failure of building components, including, but not limited to, the roof substrate, walls, mortar, HVAC units, non-Carlisle brand metal work, etc., occurs and causes a leak, or otherwise damages the Carlisle Total Roofing System; or
  - Acids, oils, harmful chemicals and the like come in contact with the Carlisle Total Roofing System and cause a leak, or otherwise damage the Carlisle Total Roofing System.
  - The Carlisle Total Roofing System encounters leaks or is otherwise damaged by condensation resulting from any condition within the building that may generate moisture.
- This Warranty shall be null and void if any of the following shall occur:
  - If, after installation of the Carlisle Total Roofing System by a Carlisle Authorized Roofing Applicator there are any alterations or repairs made on or through the roof or objects such as, but not limited to, structures, fixtures, solar panels, wind turbines, roof gardens or utilities are placed upon or attached to the roof without first obtaining written authorization from Carlisle; or
  - Failure by the Owner to use reasonable care in maintaining the roof, said maintenance to include, but not be limited to, those items listed on Carlisle's Care & Maintenance Information sheet which accompanies this Warranty.
- Only Carlisle brand insulation products are covered by this warranty. Carlisle specifically disclaims liability, under any theory of law, for damages sustained by or caused by non-Carlisle brand insulation products.
- During the term of this Warranty, Carlisle shall have free access to the roof during regular business hours.
- Carlisle shall have no obligation under this Warranty while any bills for installation, supplies, service, and warranty charges have not been paid in full to the Carlisle Authorized Roofing Applicator, Carlisle, or material suppliers.
- Carlisle's failure at any time to enforce any of the terms or conditions stated herein shall not be construed to be a waiver of such provision.
- Carlisle shall not be responsible for the cleanliness or discoloration of Carlisle Total Roofing System caused by environmental conditions including, but not limited to, dirt, pollutants or biological agents.
- Carlisle shall have no liability under any theory of law for any claims, repairs, restoration, or other damages including, but not limited to, consequential or incidental damages relating, directly or indirectly, to the presence of any irritants, contaminants, vapors, fumes, molds, fungi, bacteria, spores, mycotoxins, or the like in the building or in the air, land, or water serving the building.
- This warranty shall be transferable upon a change in ownership of the building when the owner has completed certain procedures including a transfer fee and an inspection of the Roofing System by a Carlisle representative.

CARLISLE DOES NOT WARRANT PRODUCTS UTILIZED IN THIS INSTALLATION WHICH IT HAS NOT FURNISHED; AND SPECIFICALLY DISCLAIMS LIABILITY, UNDER ANY THEORY OF LAW, ARISING OUT OF THE INSTALLATION AND PERFORMANCE OF, OR DAMAGES SUSTAINED BY OR CAUSED BY, PRODUCTS NOT FURNISHED BY CARLISLE OR THE PRIOR EXISTING ROOFING MATERIAL OVER WHICH THE CARLISLE ROOFING SYSTEM HAS BEEN INSTALLED.

THE REMEDIES STATED HEREIN ARE THE SOLE AND EXCLUSIVE REMEDIES FOR FAILURE OF THE CARLISLE TOTAL ROOFING SYSTEM OR ITS COMPONENTS. THERE ARE NO WARRANTIES EITHER EXPRESSED OR IMPLIED, INCLUDING THE IMPLIED WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE AND MERCHANTABILITY, WHICH EXTEND BEYOND THE FACE HEREOF. CARLISLE SHALL NOT BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR OTHER DAMAGES INCLUDING, BUT NOT LIMITED TO, LOSS OF PROFITS OR DAMAGE TO THE BUILDING OR ITS CONTENTS UNDER ANY THEORY OF LAW.

BY: Mark J. Long

AUTHORIZED SIGNATURE

TITLE: Director, Technical and Warranty Services

This Warranty Expires: December 04, 2038

P.O. Box 7000 Carlisle, PA 17013 Phone: 800.233.0551 Fax: 717.245.7121 www.carlislestynlec.com

F0001 (3/18)



## DYNACLAD® KYNAR 500® COATING 20 Year Limited Warranty

Dimensional Metals, Inc. (DMI) warrants for a period of twenty (20) years after Customer's shipment of painted products that Dimensional Metal's standard color, Medium Gloss DynaClad® coil coatings (Coatings) when applied on Galvalume, HDG-90 steel and aluminum substrate will not:

- A. Peel, flake or otherwise lose adhesion to an extent that is apparent on ordinary outdoor visual observation.
- B. Change color more than 5 Delta E Units when measured per ASTM D-2244 on clean surface.
- C. Chalk more than a number eight (8) rating when measured per ASTM D-4214.

### TERMS AND CONDITIONS

1. It is acknowledged that fading or color change may not be uniform if the surfaces are not equally exposed to the sun and elements. DMI recommends that there be a systematic fresh water rinse maintenance program in effect in areas of high salt concentration (such as adjacent to the seashore and/or industrial atmospheres) so as to prevent the accumulation of concentrated mineral deposits.
2. This Limited Warranty covers DMI Coatings exposed to normal atmospheric conditions and specifically excludes corrosive or aggressive atmospheres including direct salt spray, contact with animal or animal waste. This Limited Warranty shall not apply where coating failure is the result of physical damage resulting from fabrication or embossing operations, corrosion due to cut edge exposure, salt spray, acts of God, vandalism, any negligent acts of the Customer including, but not limited to, improper packaging, storage, shipping, or, installation which prohibit proper drainage of standing water or other such occurrences beyond DMI's control.
3. DMI's liability and the Customer's exclusive remedy for any breach of this Limited Warranty or failure of the Coatings is strictly limited to the direct cost of refinishing or replacing the failed coated metal. Refinishing of the failed coated metal shall be performed by using standard finishing practices and materials. DMI will, in all instances, be the sole judge as to whether refinishing or replacement of the failed areas is required to fulfill its obligation under this Limited Warranty and reserves the right to approve and negotiate the contract.
4. This Limited Warranty shall not be extended by the refinishing or replacement of the coated material, but the remaining warranty period shall continue in effect and be applicable to the refinished or replaced areas under the terms and conditions of the Limited Warranty.
5. Claims under this Limited Warranty must be presented in writing during the warranty period and within sixty (60) days after Customer becomes aware that any warranted condition has occurred. Time is of the essence and failure to give notice within the specified time shall discharge DMI from any obligations under this Limited Warranty. DMI must be given a reasonable opportunity to an on-site inspection to determine the cause and the corrective action to be taken if it is determined to be a Coating failure.
6. THIS LIMITED WARRANTY IS GIVEN AS THE EXCLUSIVE WARRANTY AND REMEDY, AND DMI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, DMI SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES. THE CUSTOMER'S EXCLUSIVE REMEDY SHALL BE THAT SET FORTH IN PARAGRAPH 3 FOR ANY CLAIM OF LIABILITY RELATING TO THE COATINGS UNDER NEGLIGENCE, STRICT LIABILITY, BREACH OF WARRANTY, OR ANY OTHER LEGAL THEORY.
7. This Limited Warranty is extended to Customer alone, is nontransferable and non-assignable, and may not be modified or enlarged in its scope by any representative, salesman, agent, or other employee of DMI. Customer shall not permit anyone to claim or imply that this Limited Warranty extends to anyone other than Customer. This condition is a material term of this Limited Warranty and its violation by Customer or its agents or representatives shall release DMI from its obligations hereunder.
8. This Limited Warranty shall be governed by and interpreted in accordance with the laws of the State of Ohio. Jurisdiction and venue for any dispute concerning the roof or this Limited Warranty are fixed in Franklin County, Ohio.

### R1801-01 Replace Roofs - Academy Dormitory

Project Name

1510 East Elm Street

Address

Jefferson City MO 65101

City State Zip

DMI Flat Sheets in DynaClad 24ga White  
Material Description

### Missouri Builders Service, Inc.

Sold To

P.O. Box 104205

Address

Jefferson City MO 65110

City State Zip

18005509

Invoice/ (Order Number)

12/04/18

Effective Date

Dimensional Metals, Inc.

58 Klema Drive North Reynoldsburg, OH 43068 - (740) 927-3633

Signature

Title

Date



## GALVALUME SHEET 20 YEAR-6 MONTH LIMITED WARRANTY

### EXCLUSIVE WARRANTY

Dimensional Metals, Inc. 58 Klema Drive North, Reynoldsburg, Oh 43068 ("seller") hereby provides the LIMITED WARRANTY to: Missouri Builders Service, Inc. RE: R1801-01 Replace Roofs - Academy Dormitory - 12/04/18 ("Buyer"). Dimensional Metals, Inc. Warrants that, subject to the following provisions, Seller's hot dipped aluminum-zinc alloy-coated Galvalume sheet steel sold for use as steel building, roofing and siding panels, If erected within the Continental United States, WILL NOT rupture, fail structurally, or perforate within a period of 20 years and 6 months after shipment from our facility due to exposure to normal atmospheric conditions.

### EXCLUDED ATMOSPHERIC CONDITIONS

This limited warranty DOES NOT APPLY to sheets exposed at any time to corrosive or aggressive atmospheric conditions, including but not limited to:

1. Areas subject to salt-water marine atmospheres or to constant spraying of either salt or fresh water.
2. Areas subject to fallout or exposure to corrosive chemicals, fumes, ash, cement dust or animal waste.
3. Areas subject to water run-off from lead or copper flashings or areas in metallic contact with lead or copper.
4. Conditions/circumstances where corrosive fumes or condensates are generated or released inside the building,

### OTHER EXCLUDED SITUATIONS

This warranty DOES NOT APPLY in the event of:

1. Bends less than 2T for sheet thickness 0.030" and thinner and less than 4T for sheet thickness 0.031" and thicker.
2. Slopes of the roof or sections of the roof flatter than 1/4:12.
3. Mechanical, chemical, or other damage sustained during shipment, storage, forming, fabrication, or during or after erection.
4. Forming which incorporates severe reverse bending or which subjects coating to alternate compression and tension.
5. Failure to provide free drainage of water, including internal condensation, from overlaps and all other surfaces of the sheets or panels.
6. Failure to remove debris from overlaps and all other surfaces of the sheets or panels.
7. Damage caused to the metallic coating by improper roll forming, scouring or cleaning procedures.
8. Deterioration of the panels caused by contact with green or wet lumber or wet storage stain caused by water damage or condensation.
9. Presence of damp insulation or other corrosive materials in contact with or close proximity to the panel.
10. This warranty does not apply in the event of deterioration to the panels caused directly or indirectly by panel contact with fasteners. Selection of suitable long-lasting fasteners to be used with Galvalume roofing and siding panels rests solely with the Buyer.

### EXCLUSIVE REMEDIES

Buyer's exclusive remedy and Seller's sole liability for breach of this limited warranty shall be limited exclusively to the cost of either repairing nonconforming panels, or at Seller's sole option, of furnishing FOB buyer's plant sufficient sheet product to enable Buyer to fabricate replacement panels for the nonconforming panels.

### LIMITATION OF DAMAGES

THE LIABILITY OF THE SELLER SHALL NOT EXTEND TO PERSONAL INJURY, PROPERTY DAMAGE, LOSS OF PROFIT, DELAY OR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM THE FAILURE OF ANY SHEET TO CONFORM WITH THE PROVISIONS OF THIS LIMITED WARRANTY.

### OTHER WARRANTIES, INCLUDING MERCHANTABILITY

THERE ARE NO WARRANTIES, PROMISES OR AFFIRMATIONS OF FACT, INCLUDING WARRANTIES OF MERCHANTABILITY AND OF FITNESS FOR A PARTICULAR PURPOSE OTHER THAN THOSE EXPRESSLY SET FORTH HEREIN. THE CONDITIONS OF LIABILITY, RIGHTS, OBLIGATIONS AND REMEDIES OF THE PARTIES RELATING TO CLAIMS ARISING FROM ANY NONCONFORMING SHEET SHALL BE GOVERNED EXCLUSIVELY BY THE TERMS SET FORTH HEREIN.

### INSPECTIONS AND NOTICE OF CLAIM

Buyer shall exercise diligence in inspection of material as received from Seller prior to utilization so as to mitigate expense involved in repairing, repainting, or replacing nonconforming sheets. Claims for any breach of warranty must be made within the period of this limited warranty and within 30 days after Buyer discovered the nonconforming sheet, and Buyer must give Seller a reasonable opportunity to inspect the material.

### DUTIES OF BUYER IN PRESENTING CLAIMS

As a condition precedent to Seller's liability hereunder, Buyer must present with his claim such records so to enable Seller and the date of installation in the form of building panels for the claimed nonconforming sheet. Buyer shall also present such evidence that establishes any claimed nonconformance was due to a breach of the limited warranty stated herein.

### TRANSFERS REPRESENTATIONS AND ASSIGNMENTS

UNLESS EXPRESSLY AGREED IN WRITING BY AND BETWEEN BUYER AND SELLER, THIS LIMITED WARRANTY IS EXTENDED TO BUYER AS THE ORIGINAL PURCHASER FROM SELLER AND IS NON-TRANSFERABLE AND BY ANY PURPORTED TRANSFER OR ASSIGNMENT, NOR SHALL ANY RIGHT AGAINST SELLER SURVIVE ANY TRANSFER OR ASSIGNMENT. BUYER OR ITS AGENTS OR REPRESENTATIVES SHALL NOT CLAIM, REPRESENT OR IMPLY NOR PERMIT ITS CUSTOMERS, DISTRIBUTORS, APPLICATORS, OR CONTRACTORS TO CLAIM, REPRESENT OR IMPLY THAT THIS LIMITED WARRANTY EXTENDS OR IS AVAILABLE TO PARTIES OTHER THAN THE PARTY TO THIS WARRANTY. THIS CONDITION SHALL CONSTITUTE A MATERIAL TERM OF THIS LIMITED WARRANTY AND ITS VIOLATION BY BUYER SHALL EXCUSE SELLER FROM ITS OBLIGATIONS HEREUNDER.

### WAIVER OR MODIFICATIONS OF SELLER'S RIGHTS

No terms or conditions, other than those stated herein, and no agreement or understanding, oral or written, and no course of conduct or performance, in any way purporting to modify this limited warranty or to waive Seller's rights hereunder, shall be binding on Seller unless the same be clearly set forth in a writing that expressly refers to this limited warranty and expressly refers to having such effect upon this limited warranty is signed by the authorized representative of Seller.

### TERMINATION

Seller reserves the right to terminate this limited warranty, except with respect to orders, which it has already accepted, upon the giving of written notice thereof.

### GOVERNING LAW

The substantive law of the State of Ohio shall of exclusively govern the rights and duties of the parties under this agreement.

### ENTIRE AGREEMENT

The provisions set forth herein are in lieu of and expressly supersede any other provisions irrespective of where contained. All proposals, negotiations and representations, if any, made prior to or with reference hereto are merged herein.

  
Signature \_\_\_\_\_ Title \_\_\_\_\_ Date 12/13/18  
Dimensional Metals, Inc.



STATE OF MISSOURI  
OFFICE OF ADMINISTRATION  
DIVISION OF FACILITIES MANAGEMENT, DESIGN AND CONSTRUCTION  
**ROOFING SYSTEM DESCRIPTION**

EXHIBIT COPY

PROJECT NUMBER  
**R1801-01**

**GENERAL INFORMATION**

|                                                  |  |                          |                        |                                                        |             |                          |
|--------------------------------------------------|--|--------------------------|------------------------|--------------------------------------------------------|-------------|--------------------------|
| AGENCY NAME<br>Missouri State Highway Patrol     |  |                          |                        |                                                        |             |                          |
| AGENCY CODE<br>PS-11                             |  | FACILITY NUMBER<br>55105 |                        | SITE NUMBER<br>4751                                    |             |                          |
| BUILDING NAME<br>Administration Building         |  |                          |                        |                                                        |             |                          |
| BUILDING ADDRESS<br>1510 East Elm Street         |  |                          | CITY<br>Jefferson City |                                                        | STATE<br>MO | ZIP CODE<br>65101        |
| DATE OF ROOF COMPLETION<br>12-4-18               |  | ROOF SLOPE<br>Flat       |                        | ROOF AREA<br>12,182sf                                  |             | ROOF HEIGHT (AGL)<br>N/A |
| ROOF CONSULTANT<br>The Architects Alliance, Inc. |  |                          |                        | BUILDING USE<br>Administration                         |             |                          |
| ROOF ACCESS<br>Hatch                             |  |                          |                        | ADMIN/INSPT<br>Tina Brown                              |             |                          |
| WARRANTY<br>20 Year                              |  |                          |                        | ROOF MANUFACTURER<br>Carlisle                          |             |                          |
| ROOF INSTALLER<br>Missouri Builders Service      |  |                          |                        | GENERAL CONTRACTOR<br>None - Missouri Builders Service |             |                          |

| COMPONENT                                                                                                  | TYPE           | COMMENTS                                                                                |
|------------------------------------------------------------------------------------------------------------|----------------|-----------------------------------------------------------------------------------------|
| <b>SURFACING</b><br>RIVER GRAVEL, PEA GRAVEL,<br>COATING, PAVERS, NONE                                     | None           |                                                                                         |
| <b>MEMBRANE</b><br>BUILT-UP, EDPM-FA, EDPM-B,<br>EDPM-MF, METAL-SS, METAL-AR,<br>SHINGLE, PVC, FOAM, OTHER | TPO            | DynaClad Kynar 500 24ga White Coping, TPO - Carlisle 115MIL Sure-Weld Fleece Back White |
| <b>INSULATION</b><br>POLYSTYRENE, ISO BOARD,<br>FIBERGLASS, FIBERBOARD, PERLITE,<br>URETHANE, NONE, OTHER  | ISO            |                                                                                         |
| THICKNESS                                                                                                  | 4"             | Varies from Drian to Ridge, Average 4"                                                  |
| ATTACHMENT                                                                                                 | Mech/Adhesive  |                                                                                         |
| <b>VAPOR BARRIER</b><br>KRAFT, FELT, ALUMINUM FOIL,<br>POLY, PLASTIC, OTHER                                | N/A            |                                                                                         |
| <b>DECK</b><br>STEEL, WOOD, GYPSUM (SLAB OR<br>PLANK), LT. WT. CON., REG. CON.,<br>OTHER                   | Steel Deck     |                                                                                         |
| <b>STRUCTURAL SYS.</b><br>STEEL JOIST, WOOD TRUSSES,<br>CONCRETE, METAL PURLINS                            | Concrete/Steel |                                                                                         |

**DESCRIPTION OF ROOF-TOP ACCESSORIES**

A flat roof systems comprised of existing roof deck construction, existing ISO roofing insulation, with wood fiber coverboard and EPDM membrane which received a new roofing membrane covering (DynaClad Kynar 500) adhered over exisiting membrane. Isolated areas identified with an infrared imaging system as wet or damaged areas were removed to deck and replaced matching existing systems and final covering. Other accessories include new Roof Hatch, Saffety Post, Roof Hatch Railing and without Gate, raised roof equipment curbs, re-covered RTU intake and exhaust shrouds, new walk mats, new strainer basket, and new prefinished metal roof copings.



8. ROOFING  
SYSTEM  
DESCRIPTION -  
DORMITORY BLDG

G  
A  
N  
A  
F

RATION  
ES MANAGEMENT, DESIGN AND CONSTRUCTION  
M DESCRIPTION

PROJECT NUMBER  
R1801-01

FACILITY NUMBER  
55104

SITE NUMBER  
4751

BUILDING NAME

Dormitory Building

BUILDING ADDRESS

1510 East Elm Street

CITY

Jefferson City

STATE

MO

ZIP CODE

65101

DATE OF ROOF COMPLETION

12-4-18

ROOF SLOPE

Flat

ROOF AREA

12,182sf

ROOF HEIGHT (AGL)

N/A

ROOF CONSULTANT

The Architects Alliance, Inc.

BUILDING USE

Housing

ROOF ACCESS

Hatch

ADMIN/INSPT

Tina Brown

WARRANTY

20 Year

ROOF MANUFACTURER

Carlisle

ROOF INSTALLER

Missouri Builders Service

GENERAL CONTRACTOR

None - Missouri Builders Service

| COMPONENT                                                                                                  | TYPE           | COMMENTS                                                                                   |
|------------------------------------------------------------------------------------------------------------|----------------|--------------------------------------------------------------------------------------------|
| <b>SURFACING</b><br>RIVER GRAVEL, PEA GRAVEL,<br>COATING, PAVERS, NONE                                     | None           |                                                                                            |
| <b>MEMBRANE</b><br>BUILT-UP, EDPM-FA, EDPM-B,<br>EDPM-MF, METAL-SS, METAL-AR,<br>SHINGLE, PVC, FOAM, OTHER | TPO            | DynaClad Kynar 500 24ga White Coping, TPO - Carlisle 115MIL Sure-Weld<br>Fleece Back White |
| <b>INSULATION</b><br>POLYSTYRENE, ISO BOARD,<br>FIBERGLASS, FIBERBOARD, PERLITE,<br>URETHANE, NONE, OTHER  | ISO            |                                                                                            |
| THICKNESS                                                                                                  | 4"             | Varies from Drian to Ridge, Average 4"                                                     |
| ATTACHMENT                                                                                                 | Mech/Adhesive  |                                                                                            |
| <b>VAPOR BARRIER</b><br>KRAFT, FELT, ALUMINUM FOIL,<br>POLY, PLASTIC, OTHER                                | N/A            |                                                                                            |
| <b>DECK</b><br>STEEL, WOOD, GYPSUM (SLAB OR<br>PLANK), LT. WT. CON., REG. CON.,<br>OTHER                   | Steel Deck     |                                                                                            |
| <b>STRUCTURAL SYS.</b><br>STEEL JOIST, WOOD TRUSSES,<br>CONCRETE, METAL PURLINS                            | Concrete/Steel |                                                                                            |

#### DESCRIPTION OF ROOF-TOP ACCESSORIES

A flat roof systems comprised of existing roof deck construction, existing ISO roofing insulation, with wood fiber coverboard and EPDM membrane which received a new roofing membrane covering (DynaClad Kynar 500) adhered over existing membrane. Isolated areas identified with an infrared imaging system as wet or damaged areas were removed to deck and replaced matching existing systems and final covering. Other accessories include new Roof Hatch, Safety Post, Roof Hatch Railing and without Gate, raised roof equipment curbs, Rain shroud at Elevator Tower, New Elevator Tower Roofing and Coping, new walk mats, Two new roof drains and new prefinished metal roof copings.



## Exhibit B



**SCI ENGINEERING, INC.**

**EARTH • SCIENCE • SOLUTIONS**

GEOTECHNICAL  
ENVIRONMENTAL  
NATURAL RESOURCES  
CULTURAL RESOURCES  
CONSTRUCTION SERVICES

January 27, 2025

Mike Sundermeyer  
CASCO Corporation  
12 Sunnen Drive, Suite 100  
St. Louis, Missouri 63143

RE: Asbestos Survey Activities  
Missouri State Highway Patrol Headquarters  
Jefferson City, Missouri  
SCI No. 2010-6100.20

Dear Mike Sundermeyer:

## **INTRODUCTION**

SCI Engineering, Inc. (SCI) is pleased to submit this report of the analytical test results for samples of suspect asbestos-containing materials (ACMs) collected during the survey performed on January 9, and January 10, 2025. The survey was conducted by Kieran Kleinhenz, Missouri-Licensed Asbestos Inspector. A copy of Kieran's asbestos inspector license is enclosed.

The purpose of this survey was to identify ACMs in accessible areas of the Academy Administration Building, the Academy Physical Training Building and the Academy Dormitory in Jefferson City, Missouri. This survey is intended to satisfy the requirements for the asbestos National Emission Standard for Hazardous Air Pollutants (NESHAP) for demolition and renovation. It is also intended to be used for Occupational Safety and Health Administration (OSHA) compliance.

The on-site structures are an approximate 13,000 square-foot dormitory, a 17,500 square-foot physical training building, and a 22,500 square-foot administration building all which appeared to have been constructed in the 1971. The exterior of the structures were brick and plaster siding with metal windows, and a flat membrane roof. The structures utilized a boiler HVAC system.

## **LIMITATIONS**

SCI's asbestos survey entailed visually assessing accessible areas only. If any other suspect asbestos materials are discovered during demolition or renovation, please contact SCI, and we will make arrangements for assessment of these materials. Areas behind walls, under subfloors and above fixed ceilings are considered non-accessible.

During the course of performing the survey of the structure, SCI was able to access all locations within the structures, however, SCI was unable to access most of the roofs due to snow and ice coverage.

## ASBESTOS SURVEY

One hundred and ten samples were collected from the on-site structure. Of these 110 samples, 104 were analyzed by Polarized Light Microscopy (PLM) using a positive stop procedure. Of the 104 samples, 5 were found to contain asbestos. Analytical test results and chain-of-custody documentation are enclosed. The results of the analysis of all samples are summarized in Table 1.

**Table 1 - Summary of Analytical Test Results (Continued)**

| Sample Number | Material Location                                                                                | Material Description                                   | Approx. Quantity | Result                                                    | Category |
|---------------|--------------------------------------------------------------------------------------------------|--------------------------------------------------------|------------------|-----------------------------------------------------------|----------|
| 10-6100-1A    | Academy Building and Dorm Building - Throughout                                                  | 4" Dark Brown Covebase with Tan Mastic                 | --               | None Detected in Covebase or Mastic                       | --       |
| 10-6100-1B    |                                                                                                  |                                                        |                  | None Detected in Covebase or Mastic                       |          |
| 10-6100-1C    |                                                                                                  |                                                        |                  | None Detected in Covebase or Mastic                       |          |
| 10-6100-2     | VOID                                                                                             | Sample Not Needed                                      | --               | VOID                                                      | VOID     |
| 10-6100-3A    | Academy Building – Office/Lobby Area                                                             | 2' by 2' Pinhole Wormtrack Ceiling Tile                | --               | None Detected                                             | --       |
| 10-6100-3B    |                                                                                                  |                                                        |                  | None Detected                                             |          |
| 10-6100-3C    |                                                                                                  |                                                        |                  | None Detected                                             |          |
| 10-6100-4A    | Academy Building – Throughout Complex                                                            | 1' by 1' Pinhole Ceiling Tile with Yellow Mastic Pucks | 100 sf           | None Detected in Ceiling Tile or Mastic                   | --       |
| 10-6100-4B    |                                                                                                  |                                                        |                  | None Detected in Ceiling Tile or Mastic                   |          |
| 10-6100-4C    |                                                                                                  |                                                        |                  | None Detected in Ceiling Tile or Mastic                   |          |
| 10-6100-5A    | Throughout Complex                                                                               | Brown Stair Tread with Brown Mastic                    | --               | None Detected in Stair Tread, Tan Mastic, or Brown Mastic | --       |
| 10-6100-5B    |                                                                                                  |                                                        |                  | None Detected in Stair Tread, Tan Mastic, or Brown Mastic |          |
| 10-6100-5C    |                                                                                                  |                                                        |                  | None Detected in Stair Tread, Tan Mastic, or Brown Mastic |          |
| 10-6100-6A    | Academy Building Throughout and Dorm Building First Floor Offices, Second/Third Floor Throughout | 4" Grey Covebase with Tan Mastic                       | --               | None Detected in Covebase or Mastic                       | --       |
| 10-6100-6B    |                                                                                                  |                                                        |                  | None Detected in Covebase or Mastic                       |          |
| 10-6100-6C    |                                                                                                  |                                                        |                  | None Detected in Covebase or Mastic                       |          |
| 10-6100-7A    | Common Bathrooms                                                                                 | Bathroom Caulk on Sinks, Toilets, and Urinals          | 240 lf           | None Detected                                             | --       |
| 10-6100-7B    |                                                                                                  |                                                        |                  | None Detected                                             |          |
| 10-6100-7C    |                                                                                                  |                                                        |                  | None Detected                                             |          |

sf - square feet  
lf - linear feet

**Table 1 - Summary of Analytical Test Results (Continued)**

| Sample Number | Material Location                                                                   | Material Description                                                       | Approx. Quantity | Result                                                                                                                    | Category |
|---------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------|------------------|---------------------------------------------------------------------------------------------------------------------------|----------|
| 10-6100-8A    | Throughout Complex                                                                  | Plaster Board Wall System                                                  | --               | None Detected in Plaster                                                                                                  | --       |
| 10-6100-8B    |                                                                                     |                                                                            |                  | None Detected in Plaster                                                                                                  |          |
| 10-6100-8C    |                                                                                     |                                                                            |                  | None Detected in Plaster                                                                                                  |          |
| 10-6100-9A    | Academy Building – Classrooms B,C,D,E, Hallways, Mech. Rooms, Kitchen, Media Office | 12" by 12" Tan with Brown Mottle Floor Tile with Black Mastic, On Concrete | 10,100 sf        | 5% Chrysotile Detected in Floor Tile; None Detected in Tan Mastic; 8% Chrysotile Detected in Black Mastic                 | NCI      |
| 10-6100-9B    |                                                                                     |                                                                            |                  | Floor Tile Not Analyzed Due to Positive Stop; None Detected in Tan Mastic; Black Mastic Not Analyzed Due to Positive Stop |          |
| 10-6100-9C    |                                                                                     |                                                                            |                  | Floor Tile Not Analyzed Due to Positive Stop; None Detected in Tan Mastic; Black Mastic Not Analyzed Due to Positive Stop |          |
| 10-6100-10A   | Throughout Complex                                                                  | 4" Light Brown Covebase with White Mastic                                  | --               | None Detected on Covebase or Mastic                                                                                       | --       |
| 10-6100-10B   |                                                                                     |                                                                            |                  | None Detected on Covebase or Mastic                                                                                       |          |
| 10-6100-10C   |                                                                                     |                                                                            |                  | None Detected on Covebase or Mastic                                                                                       |          |
| 10-6100-11A   | All Buildings – All Doors and Windows (Interior and Exterior)                       | Grey Door/Window Caulk                                                     | 4,000 lf         | None Detected                                                                                                             | --       |
| 10-6100-11B   |                                                                                     |                                                                            |                  | None Detected                                                                                                             |          |
| 10-6100-11C   |                                                                                     |                                                                            |                  | None Detected                                                                                                             |          |
| 10-6100-12A   | Throughout Complex                                                                  | 2' by 4' Pinhole Wormtrack Ceiling Tile                                    | --               | None Detected                                                                                                             | --       |
| 10-6100-12B   |                                                                                     |                                                                            |                  | None Detected                                                                                                             |          |
| 10-6100-12C   |                                                                                     |                                                                            |                  | None Detected                                                                                                             |          |
| 10-6100-13A   | Throughout Complex on Most Walls                                                    | Wall Texture                                                               | --               | None Detected                                                                                                             | --       |
| 10-6100-13B   |                                                                                     |                                                                            |                  | None Detected                                                                                                             |          |
| 10-6100-13C   |                                                                                     |                                                                            |                  | None Detected                                                                                                             |          |
| 10-6100-14A   | Academy Building – Classroom E, Kit Off, Multimedia Hallway                         | 12" by 12" White Replacement Floor Tile with Tan Mastic, On Concrete       | 220 sf           | None Detected in Floor Tile or Mastic                                                                                     | --       |
| 10-6100-14B   |                                                                                     |                                                                            |                  | None Detected in Floor Tile or Mastic                                                                                     |          |
| 10-6100-14C   |                                                                                     |                                                                            |                  | None Detected in Floor Tile or Mastic                                                                                     |          |

sf - square feet

lf - linear feet

NCI - Non-Friable Category I Material

**Table 1 - Summary of Analytical Test Results (Continued)**

| Sample Number | Material Location                          | Material Description                                | Approx. Quantity | Result                                           | Category |
|---------------|--------------------------------------------|-----------------------------------------------------|------------------|--------------------------------------------------|----------|
| 10-6100-15A   | Throughout Complex                         | 4" Tan Covebase with Tan Mastic                     | --               | None Detected on Covebase or Mastic              | --       |
| 10-6100-15B   |                                            |                                                     |                  | None Detected on Covebase or Mastic              |          |
| 10-6100-15C   |                                            |                                                     |                  | None Detected on Covebase or Mastic              |          |
| 10-6100-16A   | Academy Building Kitchen                   | Black Sink Coating (On 6 Sinks)                     | 18 sf            | 9% Chrysotile Detected in Sink Coating           | NCII     |
| 10-6100-16B   |                                            |                                                     |                  | Not Analyzed Due to Positive Stop                |          |
| 10-6100-16C   |                                            |                                                     |                  | Not Analyzed Due to Positive Stop                |          |
| 10-6100-17A   | Throughout Academy Building                | Expansion Joint Caulk between Plaster and CMU Walls | 50 lf            | None Detected                                    | --       |
| 10-6100-17B   |                                            |                                                     |                  | None Detected                                    |          |
| 10-6100-17C   |                                            |                                                     |                  | None Detected                                    |          |
| 10-6100-18A   | Throughout Complex                         | Duct Tape                                           | 500 sf           | None Detected in Wrap or Adhesive                | --       |
| 10-6100-18B   |                                            |                                                     |                  | None Detected in Wrap or Adhesive                |          |
| 10-6100-18C   |                                            |                                                     |                  | None Detected in Wrap or Adhesive                |          |
| 10-6100-19A   | Kitchen                                    | Wall Ceramic Tile Repair Caulk                      | 110 lf           | None Detected                                    | --       |
| 10-6100-19B   |                                            |                                                     |                  | None Detected                                    |          |
| 10-6100-19C   |                                            |                                                     |                  | None Detected                                    |          |
| 10-6100-20    | Academy Building                           | Roof Core                                           | --               | None Detected in Rubber, Adhesive, or Insulation | --       |
| 10-6100-21A   | Lower Roof/Upper Roof Upper Layer Flashing | White Flashing Sealant Caulk                        | 1,100 lf         | None Detected                                    | --       |
| 10-6100-21B   |                                            |                                                     |                  | None Detected                                    |          |
| 10-6100-21C   |                                            |                                                     |                  | None Detected                                    |          |
| 10-6100-22A   | Upper Roof Lower Layer Flashing            | Grey Flashing Sealant Caulk                         | 460 lf           | None Detected                                    |          |
| 10-6100-22B   |                                            |                                                     |                  | None Detected                                    |          |
| 10-6100-22C   |                                            |                                                     |                  | None Detected                                    |          |
| 10-6100-23A   | Throughout Complex                         | Pipe Insulation Wrap                                | 5,000 sf         | None Detected in Wrap or Adhesive                |          |
| 10-6100-23B   |                                            |                                                     |                  | None Detected in Wrap or Adhesive                |          |
| 10-6100-23C   |                                            |                                                     |                  | None Detected in Wrap or Adhesive                |          |
| 10-6100-24    | Throughout Complex                         | Mudded Fittings                                     | 25 fittings      | None Detected in Wrap or Adhesive                | --       |
| 10-6100-25A   | Dorm Building – Boiler Room                | Foam/Fiberglass Ceiling Tile Brown Mastic Pucks     | 100 sf           | None Detected                                    | --       |
| 10-6100-25B   |                                            |                                                     |                  | None Detected                                    |          |
| 10-6100-25C   |                                            |                                                     |                  | None Detected                                    |          |

sf - square feet  
lf - linear feet

**Table 1 - Summary of Analytical Test Results (Continued)**

| Sample Number | Material Location                                                        | Material Description                                                       | Approx. Quantity | Result                                | Category |
|---------------|--------------------------------------------------------------------------|----------------------------------------------------------------------------|------------------|---------------------------------------|----------|
| 10-6100-26A   | Dorm Building – Boiler Room                                              | Foam/Fiberglass Ceiling Tile Black Mastic Pucks                            | 100 sf           | None Detected                         | --       |
| 10-6100-26B   |                                                                          |                                                                            |                  | None Detected                         |          |
| 10-6100-26C   |                                                                          |                                                                            |                  | None Detected                         |          |
| 10-6100-27    | VOID                                                                     | Duplicate Sample                                                           | --               | VOID                                  | VOID     |
| 10-6100-28A   | Dorm Building – Boiler Room                                              | White Boiler Expansion Tank Wrap                                           | 40 sf            | None Detected                         | --       |
| 10-6100-28B   |                                                                          |                                                                            |                  | None Detected                         |          |
| 10-6100-28C   |                                                                          |                                                                            |                  | None Detected                         |          |
| 10-6100-29    | VOID                                                                     | Duplicate Sample                                                           | --               | VOID                                  | VOID     |
| 10-6100-30A   | Dorm Building – Boiler Rooms, on Boiler Circulation Pump Line Insulation | Pinkish-Tan Sealant Caulk                                                  | 15 lf            | None Detected                         | --       |
| 10-6100-30B   |                                                                          |                                                                            |                  | None Detected                         |          |
| 10-6100-30C   |                                                                          |                                                                            |                  | None Detected                         |          |
| 10-6100-31A   | Dorm Building – First Floor Throughout                                   | 12” by 12” White with White Mottle Floor Tile with Tan Mastic, On Concrete | 3,400 sf         | None Detected in Floor Tile or Mastic | --       |
| 10-6100-31B   |                                                                          |                                                                            |                  | None Detected in Floor Tile or Mastic |          |
| 10-6100-31C   |                                                                          |                                                                            |                  | None Detected in Floor Tile or Mastic |          |
| 10-6100-32A   | Academy Building Lobby Area, Dorm Building First Floor                   | 6” Dark Brown Covebase                                                     | --               | None Detected on Covebase or Mastic   | --       |
| 10-6100-32B   |                                                                          |                                                                            |                  | None Detected on Covebase or Mastic   |          |
| 10-6100-32C   |                                                                          |                                                                            |                  | None Detected on Covebase or Mastic   |          |
| 10-6100-33A   | Dorm Building Interior Windows                                           | White Interior Window Caulk                                                | 320 lf           | None Detected                         | --       |
| 10-6100-33B   |                                                                          |                                                                            |                  | None Detected                         |          |
| 10-6100-33C   |                                                                          |                                                                            |                  | None Detected                         |          |
| 10-6100-34A   | Dorm Building / First/Second Floor Hall/Rooms                            | Thinner Layer Popcorn Ceiling                                              | 10,500 sf        | 3% Chrysotile Detected                | Friable  |
| 10-6100-34B   |                                                                          |                                                                            |                  | Not Analyzed Due to Positive Stop     |          |
| 10-6100-34C   |                                                                          |                                                                            |                  | Not Analyzed Due to Positive Stop     |          |
| 10-6100-35A   | Dorm Building Second Floor Hall                                          | White Terrazzo Floor Tile                                                  | 1,000 sf         | None Detected in Floor Tile or Grout  | --       |
| 10-6100-35B   |                                                                          |                                                                            |                  | None Detected in Floor Tile or Grout  |          |
| 10-6100-35C   |                                                                          |                                                                            |                  | None Detected in Floor Tile or Grout  |          |

sf - square feet

lf - linear feet

**Table 1 - Summary of Analytical Test Results (Continued)**

| Sample Number | Material Location                                           | Material Description                        | Approx. Quantity | Result                                                                                     | Category |
|---------------|-------------------------------------------------------------|---------------------------------------------|------------------|--------------------------------------------------------------------------------------------|----------|
| 10-6100-36A   | Dorm Building / Third Floor Hall/Rooms                      | Thicker Layer Popcorn Ceiling               | 8,100 sf         | None Detected                                                                              | --       |
| 10-6100-36B   |                                                             |                                             |                  | None Detected                                                                              |          |
| 10-6100-36C   |                                                             |                                             |                  | None Detected                                                                              |          |
| 10-6100-37A   | Dorm Building / Throughout in Dorm Room Bathrooms           | White Sealant Caulk                         | 3,000 sf         | None Detected                                                                              | --       |
| 10-6100-37B   |                                                             |                                             |                  | None Detected                                                                              |          |
| 10-6100-37C   |                                                             |                                             |                  | None Detected                                                                              |          |
| 10-6100-38A   | Physical Training Building Gym Floor, Basement Hall         | 12" by 12" White with Tan Mottle Floor Tile | 10,500 sf        | 6% Chrysotile Detected in Floor Tile;<br>9% Chrysotile Detected in Black Mastic            | NCI      |
| 10-6100-38B   |                                                             |                                             |                  | Not Analyzed Due to Positive Stop                                                          |          |
| 10-6100-38C   |                                                             |                                             |                  | Not Analyzed Due to Positive Stop                                                          |          |
| 10-6100-39A   | Physical Training Building Shooting Range Area, Lower Level | 12" by 12" Grey Mottle Floor Tile           | 1,500 sf         | None Detected in Floor Tile, Tan Mastic;<br>6% Chrysotile Detected in Black Mastic         | NCI      |
| 10-6100-39B   |                                                             |                                             |                  | None Detected in Floor Tile, Tan Mastic;<br>Black Mastic Not Analyzed Due to Positive Stop |          |
| 10-6100-39C   |                                                             |                                             |                  | None Detected in Floor Tile, Tan Mastic;<br>Black Mastic Not Analyzed Due to Positive Stop |          |
| 10-6100-40A   | Exterior of Dorm Building                                   | Brown Surfacing Plaster                     | 7,000 sf         | None Detected                                                                              | --       |
| 10-6100-40B   |                                                             |                                             |                  | None Detected                                                                              |          |
| 10-6100-40C   |                                                             |                                             |                  | None Detected                                                                              |          |
| 10-6100-41A   | Exterior of All Buildings                                   | Tan Surfacing Texture                       | 15,000 sf        | None Detected                                                                              | --       |
| 10-6100-41B   |                                                             |                                             |                  | None Detected                                                                              |          |
| 10-6100-41C   |                                                             |                                             |                  | None Detected                                                                              |          |

sf - square feet

NCI - Non-Friable Category I Material

## DEMOLITION/RENOVATION

According to the Missouri Department of Natural Resources (MDNR), any friable or potentially friable ACM equal to or greater than 260 linear feet or 160 square feet is classified as a regulated ACM (RACM) and must be removed prior to demolition or renovation which would significantly damage the material.

The thinner layer of popcorn ceiling texture on the first and second floors of the Academy Dormitory (Sample 10-6100-34ABC) is a friable material and exceeds the minimum quantity requirements. This material, therefore, must be removed from the structure prior to any renovation activities which impact the material.

The black sink coating in the Academy Building kitchen (Sample 10-6100-16ABC) is a Category II non-friable material and according to the rule outlined above, is not, by definition, an RACM. However, it is the opinion of the MDNR that renovation activities will render the sink coating friable and therefore this material must be removed prior to renovation.

The 12" by 12" tan with brown mottle floor tile and black mastic in the Academy Building Classrooms B,C,D,E, hallways, mechanical rooms, kitchen, and media office (Sample 10-6100-9ABC), and the 12" by 12" white with tan mottle floor tile and black mastic on the Physical Training Building gym floor and basement hallway (Sample 10-6100-38ABC) is a Category I non-friable material and would not normally require removal. However, should renovation activities impact this material, it should be removed by a licensed abatement contractor. Alternatively, new flooring systems can be laid on top of the existing floor tile/floor tile mastic.

The floor tile black mastic in the Shooting Range in the Physical Training Building (Sample 10-6100-39ABC) is a Category I non-friable material and would not normally require removal. However, should renovation activities impact this material, it should be removed by a licensed abatement contractor. Alternatively, new flooring systems can be laid on top of the existing floor tile/floor tile mastic.

Although no asbestos-containing thermal system insulation (TSI) was observed in this structure, it is possible that asbestos-containing TSI is present in the wall cavities and floor cavities of the building where piping is present due to the construction date of the building. If any suspect pipe insulation is encountered during renovation, please contact SCI for analysis of the materials.

The Occupational Safety & Health Administration also has regulations (29 CFR Parts 1910 et al, Occupational Exposure to Asbestos, August 10, 1994) regarding removal of asbestos-containing materials which must be followed.

## **REPORTING**

Attached is Missouri Department of Natural Resources' (MDNR) Notification of Demolition and Renovation form, which has been filled out to the extent possible by SCI. The remaining information must be completed by you.

This report, as well as the completed EPA Notification of Demolition and Renovation form, must be submitted to MDNR, Air Pollution Control, PO Box 176, Jefferson City, Missouri, 65102, Stephanie Hamilton at [asbestosnotifications@dnr.mo.gov](mailto:asbestosnotifications@dnr.mo.gov).

It should be noted that following submittal of the notification form, there is a 10-day waiting period before demolition, renovation, or abatement activities can begin.

If this report is to be used for bidding purposes for asbestos abatement, SCI recommends the contractor visit the site to verify all conditions and quantities.



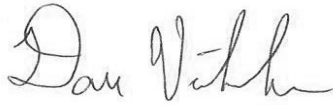
SCI appreciates the opportunity to be of service to you on this project. Please contact us if you have any questions or comments regarding the information provided.

Respectfully,

**SCI ENGINEERING, INC.**



Kieran Kleinhenz  
Missouri State Certified Asbestos Inspector  
Certificate Number 7011082924MOIR23121



Daniel P. Vielweber  
Staff Scientist

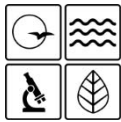


Jessica B. Keeven, CHMM  
Environmental Services Manager

KK/DPV/JBK/bmw

Enclosures

MDNR Notification of Demolition and Renovation  
Analytical Test Results and Chain of Custody  
Asbestos Inspector Certificate



MISSOURI DEPARTMENT OF NATURAL RESOURCES  
AIR POLLUTION CONTROL PROGRAM

**ASBESTOS NESHAP NOTIFICATION OF DEMOLITION AND RENOVATION**

**GENERAL INSTRUCTIONS**

**NOTE: There is a \$100 review fee for this notification. Make checks payable to the department's Air Pollution Control Program or the appropriate local agency.**

1. First-time notices = "Original." Amended projects = "Revision." Notice of cancellation = "Cancelled."
2. In the event that no asbestos removal was necessary, indicate "N/A" for asbestos removal contractor.
3. Indicate the type of project.
4. Mark the "YES" box if asbestos is present. In the next box, indicate what types of asbestos materials are present. Mark the "NO" box if no asbestos is present.
5. Failure to complete this section will result in an unapproved project. Include building uses, sizes and age. If you do not know the exact information, give your best estimate.
6. All regulated structures must be inspected by a certified asbestos inspector prior to renovation or demolition. Typically: "Certified asbestos inspector, with sample analysis by PLM." If other methods were used, explain.
7. All asbestos materials present in the building must be included here. Enter amounts (in ft<sup>2</sup>, linear feet, or ft<sup>3</sup>) of material to be removed from or left in the building. For example, in the column "Nonfriable asbestos material to be removed," under subcolumn "CAT II" (on the "surface area" line) you might enter "5,200" and "transite" under the number. The inspection report, which must be attached to the notification, should reflect this information.
8. This line must be completed. Never enter a date that is not at least 10 working days after your postmark, unless you have been granted a waiver by the department. **Missouri law requires notifications to be submitted at least 10 working days in advance of the project start date.**
9. If applicable, enter the dates on which abatement will occur or has occurred.
10. Give a brief description of your demolition/renovation plans, including the scope of work to be performed and the methods used to perform the work. Use an additional page if necessary.
11. Describe how any asbestos-containing materials (ACM) involved will be removed prior to demolition/renovation. If ACM will be left in the building, then indicate precautions used to prevent ACM from being made friable. If all asbestos has been removed, "N/A."
12. Identify waste transporter.
13. Identify waste disposal site.
14. Complete this section only for ordered demolitions. Submit the order with the notification. For all others, "N/A."
15. Complete this section only for emergency renovation projects. For all other renovations, indicate "N/A."
16. Indicate what will be done in the event that friable asbestos or suspect materials are unexpectedly encountered.
17. For regulated asbestos abatement or demolition of an unsafe or damaged structure when a prior inspection has not been conducted, a person trained in the requirements of 40 CFR Part 61, Subpart M must be on site to supervise the asbestos abatement. In the event that no asbestos is present or has already been removed, mark "N/A."
18. Always sign and date this line. This form may be signed by the project owner or operator. The project approval letter will be mailed to the person who signs the notification form.

**NOTE: For all regulated demolition and renovation projects, always include a complete copy of your asbestos inspection report with the notification form.**

Send completed forms to:

Missouri Department of Natural Resources  
APCP, Asbestos  
PO Box 176  
Jefferson City, MO 65102

If using priority mail, send to:

Missouri Department of Natural Resources  
APCP, Asbestos  
1659 E. Elm St.  
Jefferson City, MO 65101



MISSOURI DEPARTMENT OF NATURAL RESOURCES  
AIR POLLUTION CONTROL PROGRAM  
**ASBESTOS NESHAP NOTIFICATION OF DEMOLITION  
AND RENOVATION**

**FOR OFFICE USE ONLY**

|               |                     |
|---------------|---------------------|
| DATE RECEIVED | POSTMARK            |
| CHECK DATE    | CHECK NUMBER        |
| CHECK AMOUNT  | NOTIFICATION NUMBER |

**There is a \$100 review fee for this notification. Processing will be delayed if notification is received without payment.**

**1. TYPE OF NOTIFICATION**

☒ O – ORIGINAL   ☐ C – CANCELLED   ☐ R – REVISION, WRITE REVISION NUMBER \_\_\_\_\_

**2. FACILITY INFORMATION (IDENTIFY OWNER, REMOVAL CONTRACTOR AND OTHER OPERATOR)**

|                             |       |          |                                 |  |
|-----------------------------|-------|----------|---------------------------------|--|
| OWNER'S NAME                |       | ADDRESS  |                                 |  |
| CITY                        | STATE | ZIP CODE | EMAIL                           |  |
| CONTACT                     | TITLE |          | TELEPHONE NUMBER WITH AREA CODE |  |
| ASBESTOS REMOVAL CONTRACTOR |       | ADDRESS  |                                 |  |
| CITY                        | STATE | ZIP CODE | EMAIL                           |  |
| CONTACT                     | TITLE |          | TELEPHONE NUMBER WITH AREA CODE |  |
| DEMOLITION CONTRACTOR       |       | ADDRESS  |                                 |  |
| CITY                        | STATE | ZIP CODE | EMAIL                           |  |
| CONTACT                     | TITLE |          | TELEPHONE NUMBER WITH AREA CODE |  |

**3. TYPE OF OPERATION**

☐ D – DEMO   ☐ O – ORDERED DEMO   ☒ R – RENOVATION   ☐ E – EMERGENCY RENOVATION

**4. IS ASBESTOS PRESENT?**

☒ YES   ☐ NO   LIST TYPE(S) OF ASBESTOS MATERIAL TO BE REMOVED  
popcorn ceiling texture, sink coating, floor tile and mastic

**5. FACILITY DESCRIPTION**

|                                                                                                         |                  |                    |                   |
|---------------------------------------------------------------------------------------------------------|------------------|--------------------|-------------------|
| BUILDING NAME<br>Academy Administration Building, Academy Physical Training Building, Academy Dormitory |                  |                    |                   |
| ADDRESS<br>1510 E Elm Street                                                                            |                  |                    |                   |
| CITY<br>Jefferson City                                                                                  | COUNTY<br>Cole   | STATE<br>MO        | ZIP CODE<br>65101 |
| SITE LOCATION                                                                                           |                  |                    |                   |
| BUILDING SIZE<br>22,500 SF, 17,500 SF, 13,000 SF                                                        | NUMBER OF FLOORS | AGE IN YEARS<br>54 |                   |
| PRESENT USE<br>Offices, Dormitory, Classrooms, Gym                                                      | PRIOR USE        |                    |                   |

**6. PROCEDURE, INCLUDING ANALYTICAL METHOD, IF APPROPRIATE, USED TO DETECT THE PRESENCE OF ASBESTOS MATERIAL. INCLUDE A COPY OF THE ASBESTOS INSPECTION.**

**7. APPROXIMATE AMOUNT OF ASBESTOS, INCLUDING:**

| A. REGULATED ACM (RACM)<br>B. CATEGORY I ACM<br>C. CATEGORY II ACM | RACM TO BE REMOVED | NONFRIABLE ASBESTOS MATERIAL TO BE REMOVED |        | NONFRIABLE ASBESTOS MATERIAL NOT TO BE REMOVED |        |
|--------------------------------------------------------------------|--------------------|--------------------------------------------|--------|------------------------------------------------|--------|
|                                                                    |                    | CAT I                                      | CAT II | CAT I                                          | CAT II |
| PIPES (LINEAR FEET)                                                |                    |                                            |        |                                                |        |
| SURFACE AREA (SQUARE FEET)<br>32,618                               | 10,500             | 22,100                                     | 18     |                                                |        |
| VOL. RACM OFF FACILITY COMPONENT (CUBIC FEET)                      |                    |                                            |        |                                                |        |

|                                                                                                                                                                                                                                                                                                                                                       |  |                                  |                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|----------------------------------|--------------------|
| <b>8. SCHEDULED DATES DEMO/RENOVATION (MM/DD/YY)</b>                                                                                                                                                                                                                                                                                                  |  |                                  |                    |
| START:                                                                                                                                                                                                                                                                                                                                                |  | COMPLETION:                      |                    |
| <b>9. SCHEDULED DATES ASBESTOS REMOVAL (MM/DD/YY)</b>                                                                                                                                                                                                                                                                                                 |  |                                  |                    |
| START:                                                                                                                                                                                                                                                                                                                                                |  | COMPLETION:                      |                    |
|                                                                                                                                                                                                                                                                                                                                                       |  | WEEKDAY WORK HOURS               | WEEKEND WORK HOURS |
| <b>10. DESCRIPTION OF PLANNED DEMOLITION OR RENOVATION WORK AND METHOD(S) TO BE USED</b>                                                                                                                                                                                                                                                              |  |                                  |                    |
|                                                                                                                                                                                                                                                                                                                                                       |  |                                  |                    |
| <b>11. DESCRIPTION OF WORK PRACTICES AND ENGINEERING CONTROLS TO BE USED TO PREVENT EMISSIONS OF ASBESTOS AT THE DEMOLITION OR RENOVATION SITE.</b>                                                                                                                                                                                                   |  |                                  |                    |
|                                                                                                                                                                                                                                                                                                                                                       |  |                                  |                    |
| <b>12. WASTE TRANSPORTER</b>                                                                                                                                                                                                                                                                                                                          |  |                                  |                    |
| NAME                                                                                                                                                                                                                                                                                                                                                  |  | ADDRESS                          |                    |
| CITY                                                                                                                                                                                                                                                                                                                                                  |  | STATE                            | ZIP CODE           |
| CONTACT PERSON                                                                                                                                                                                                                                                                                                                                        |  | TELEPHONE NUMBER WITH AREA CODE  |                    |
| <b>13. WASTE DISPOSAL SITE</b>                                                                                                                                                                                                                                                                                                                        |  |                                  |                    |
| NAME                                                                                                                                                                                                                                                                                                                                                  |  |                                  |                    |
| LOCATION                                                                                                                                                                                                                                                                                                                                              |  |                                  |                    |
| CITY                                                                                                                                                                                                                                                                                                                                                  |  | STATE                            | ZIP CODE           |
| TELEPHONE NUMBER WITH AREA CODE                                                                                                                                                                                                                                                                                                                       |  |                                  |                    |
| <b>14. IF DEMOLITION ORDERED BY A GOVERNMENT AGENCY, IDENTIFY THE AGENCY BELOW.</b>                                                                                                                                                                                                                                                                   |  |                                  |                    |
| NAME                                                                                                                                                                                                                                                                                                                                                  |  | TITLE                            |                    |
| AGENCY                                                                                                                                                                                                                                                                                                                                                |  |                                  |                    |
| DATE OF ORDER (MM/DD/YY) INCLUDE A COPY OF THE ORDER.                                                                                                                                                                                                                                                                                                 |  | DATE ORDERED TO BEGIN (MM/DD/YY) |                    |
| <b>15. FOR EMERGENCY RENOVATIONS</b>                                                                                                                                                                                                                                                                                                                  |  |                                  |                    |
| DATE AND HOUR OF EMERGENCY                                                                                                                                                                                                                                                                                                                            |  |                                  |                    |
| DESCRIPTION OF THE SUDDEN, UNEXPECTED EVENT                                                                                                                                                                                                                                                                                                           |  |                                  |                    |
| EXPLANATION OF HOW THE EVENT CAUSED UNSAFE CONDITIONS OR WOULD CAUSE EQUIPMENT DAMAGE OR AN UNREASONABLE FINANCIAL BURDEN                                                                                                                                                                                                                             |  |                                  |                    |
| <b>16. DESCRIPTION OF PROCEDURES TO BE FOLLOWED IN THE EVENT THAT UNEXPECTED ASBESTOS IS FOUND OR PREVIOUSLY NONFRIABLE ASBESTOS MATERIAL BECOMES CRUMBLED, PULVERIZED OR REDUCED TO POWDER.</b>                                                                                                                                                      |  |                                  |                    |
|                                                                                                                                                                                                                                                                                                                                                       |  |                                  |                    |
| <b>17. I CERTIFY THAT AN INDIVIDUAL TRAINED IN THE PROVISIONS OF THIS REGULATION (40 CFR PART 61, SUBPART M) WILL BE ON-SITE DURING THE DEMOLITION OR RENOVATION AND EVIDENCE THAT THE REQUIRED TRAINING HAS BEEN ACCOMPLISHED BY THIS PERSON WILL BE AVAILABLE FOR INSPECTION DURING NORMAL BUSINESS HOURS (REQUIRED 1 YEAR AFTER PROMULGATION).</b> |  |                                  |                    |
| SIGNATURE OF OWNER/OPERATOR                                                                                                                                                                                                                                                                                                                           |  |                                  | DATE               |
| <b>18. I CERTIFY THAT THE ABOVE INFORMATION IS CORRECT.</b>                                                                                                                                                                                                                                                                                           |  |                                  |                    |
| SIGNATURE OF OWNER/OPERATOR                                                                                                                                                                                                                                                                                                                           |  |                                  | DATE               |



# EMSL Analytical, Inc.

100 Green Park Industrial Court Saint Louis, MO 63123

Tel/Fax: (314) 577-0150 / (314) 776-3313

<http://www.EMSL.com> / [saintlouislal@emsl.com](mailto:saintlouislal@emsl.com)

EMSL Order: 392500085

Customer ID: SC150

Customer PO:

Project ID:

**Attention:** Dan Vielweber  
SCI Engineering, Inc.  
130 Point West Blvd.  
Saint Charles, MO 63301

**Phone:** (636) 949-8200

**Fax:** (636) 949-8269

**Received Date:** 01/13/2025 8:00 AM

**Analysis Date:** 01/16/2025 - 01/17/2025

**Collected Date:**

**Project:** MO State Highway Patrol HQ 2010.6100.20

## Test Report: Asbestos Analysis of Bulk Materials via AHERA Method 40CFR 763 Subpart E Appendix E supplemented with EPA 600/R-93/116 using Polarized Light Microscopy

| Sample                                    | Description | Appearance                           | Non-Asbestos                   |                                        | Asbestos      |
|-------------------------------------------|-------------|--------------------------------------|--------------------------------|----------------------------------------|---------------|
|                                           |             |                                      | % Fibrous                      | % Non-Fibrous                          | % Type        |
| 10-6100-1A-Cove Base<br>392500085-0001    |             | Brown<br>Non-Fibrous<br>Homogeneous  |                                | 100% Non-fibrous (Other)               | None Detected |
| 10-6100-1A-Mastic<br>392500085-0001A      |             | Tan<br>Non-Fibrous<br>Homogeneous    |                                | 100% Non-fibrous (Other)               | None Detected |
| 10-6100-1B-Cove Base<br>392500085-0002    |             | Brown<br>Non-Fibrous<br>Homogeneous  |                                | 100% Non-fibrous (Other)               | None Detected |
| 10-6100-1B-Mastic<br>392500085-0002A      |             | Tan<br>Non-Fibrous<br>Homogeneous    |                                | 100% Non-fibrous (Other)               | None Detected |
| 10-6100-1C-Cove Base<br>392500085-0003    |             | Brown<br>Non-Fibrous<br>Homogeneous  |                                | 100% Non-fibrous (Other)               | None Detected |
| 10-6100-1C-Mastic<br>392500085-0003A      |             | Tan<br>Non-Fibrous<br>Homogeneous    |                                | 100% Non-fibrous (Other)               | None Detected |
| 10-6100-3A<br>392500085-0004              |             | Tan<br>Fibrous<br>Homogeneous        | 28% Cellulose<br>47% Min. Wool | 18% Perlite<br>7% Non-fibrous (Other)  | None Detected |
| 10-6100-3B<br>392500085-0005              |             | Tan<br>Fibrous<br>Homogeneous        | 29% Cellulose<br>48% Min. Wool | 19% Perlite<br>4% Non-fibrous (Other)  | None Detected |
| 10-6100-3C<br>392500085-0006              |             | White<br>Fibrous<br>Homogeneous      | 27% Cellulose<br>36% Min. Wool | 28% Perlite<br>9% Non-fibrous (Other)  | None Detected |
| 10-6100-4A-Ceiling Tile<br>392500085-0007 |             | Tan<br>Fibrous<br>Homogeneous        | 26% Cellulose<br>45% Min. Wool | 16% Perlite<br>13% Non-fibrous (Other) | None Detected |
| 10-6100-4A-Mastic<br>392500085-0007A      |             | Yellow<br>Non-Fibrous<br>Homogeneous |                                | 100% Non-fibrous (Other)               | None Detected |
| 10-6100-4B-Ceiling Tile<br>392500085-0008 |             | Tan<br>Fibrous<br>Homogeneous        | 27% Cellulose<br>46% Min. Wool | 17% Perlite<br>10% Non-fibrous (Other) | None Detected |
| 10-6100-4B-Mastic<br>392500085-0008A      |             | Yellow<br>Non-Fibrous<br>Homogeneous |                                | 100% Non-fibrous (Other)               | None Detected |
| 10-6100-4C-Ceiling Tile<br>392500085-0009 |             | Tan<br>Fibrous<br>Homogeneous        | 25% Cellulose<br>38% Min. Wool | 24% Perlite<br>13% Non-fibrous (Other) | None Detected |
| 10-6100-4C-Mastic<br>392500085-0009A      |             | Yellow<br>Non-Fibrous<br>Homogeneous |                                | 100% Non-fibrous (Other)               | None Detected |
| 10-6100-5A-Stair Tread<br>392500085-0010  |             | Brown<br>Non-Fibrous<br>Homogeneous  |                                | 100% Non-fibrous (Other)               | None Detected |

Initial report from: 01/17/2025 17:48:34



# EMSL Analytical, Inc.

100 Green Park Industrial Court Saint Louis, MO 63123

Tel/Fax: (314) 577-0150 / (314) 776-3313

<http://www.EMSL.com> / [saintlouislabs@emsl.com](mailto:saintlouislabs@emsl.com)

EMSL Order: 392500085

Customer ID: SC150

Customer PO:

Project ID:

## Test Report: Asbestos Analysis of Bulk Materials via AHERA Method 40CFR 763 Subpart E Appendix E supplemented with EPA 600/R-93/116 using Polarized Light Microscopy

| Sample                 | Description | Appearance                 | Non-Asbestos |                                       | Asbestos      |
|------------------------|-------------|----------------------------|--------------|---------------------------------------|---------------|
|                        |             |                            | % Fibrous    | % Non-Fibrous                         | % Type        |
| 10-6100-5A-Mastic      |             | Tan                        |              | 100% Non-fibrous (Other)              | None Detected |
| 392500085-0010A        |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-5A-Mastic      |             | Brown                      |              | 100% Non-fibrous (Other)              | None Detected |
| 392500085-0010B        |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-5B-Stair Tread |             | Brown                      |              | 100% Non-fibrous (Other)              | None Detected |
| 392500085-0011         |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-5B-Mastic      |             | Tan                        |              | 100% Non-fibrous (Other)              | None Detected |
| 392500085-0011A        |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-5B-Mastic      |             | Brown                      |              | 100% Non-fibrous (Other)              | None Detected |
| 392500085-0011B        |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-5C-Stair Tread |             | Brown                      |              | 100% Non-fibrous (Other)              | None Detected |
| 392500085-0012         |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-5C-Mastic      |             | Tan                        |              | 100% Non-fibrous (Other)              | None Detected |
| 392500085-0012A        |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-5C-Mastic      |             | Brown                      |              | 100% Non-fibrous (Other)              | None Detected |
| 392500085-0012B        |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-6A-Cove Base   |             | Gray                       |              | 100% Non-fibrous (Other)              | None Detected |
| 392500085-0013         |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-6A-Mastic      |             | Tan                        |              | 100% Non-fibrous (Other)              | None Detected |
| 392500085-0013A        |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-6B-Cove Base   |             | Gray                       |              | 100% Non-fibrous (Other)              | None Detected |
| 392500085-0014         |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-6B-Mastic      |             | Tan                        |              | 100% Non-fibrous (Other)              | None Detected |
| 392500085-0014A        |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-6C-Cove Base   |             | Gray                       |              | 100% Non-fibrous (Other)              | None Detected |
| 392500085-0015         |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-6C-Mastic      |             | Tan                        |              | 100% Non-fibrous (Other)              | None Detected |
| 392500085-0015A        |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-7A             |             | White                      |              | 13% Quartz<br>87% Non-fibrous (Other) | None Detected |
| 392500085-0016         |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-7B             |             | White                      |              | 14% Quartz<br>86% Non-fibrous (Other) | None Detected |
| 392500085-0017         |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-7C             |             | White                      |              | 15% Quartz<br>85% Non-fibrous (Other) | None Detected |
| 392500085-0018         |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-8A-Plaster     |             | White                      |              | 36% Quartz<br>64% Non-fibrous (Other) | None Detected |
| 392500085-0019         |             | Non-Fibrous<br>Homogeneous |              |                                       |               |
| 10-6100-8A-Plaster     |             | Various                    |              | 16% Quartz<br>84% Non-fibrous (Other) | None Detected |
| 392500085-0019A        |             | Non-Fibrous<br>Homogeneous |              |                                       |               |

Initial report from: 01/17/2025 17:48:34



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<http://www.EMSL.com> / [saintlouislabs@emsl.com](mailto:saintlouislabs@emsl.com)

EMSL Order: 392500085

Customer ID: SC150

Customer PO:

Project ID:

## Test Report: Asbestos Analysis of Bulk Materials via AHERA Method 40CFR 763 Subpart E Appendix E supplemented with EPA 600/R-93/116 using Polarized Light Microscopy

| Sample                                     | Description | Appearance                            | <u>Non-Asbestos</u> |                                       | <u>Asbestos</u>              |
|--------------------------------------------|-------------|---------------------------------------|---------------------|---------------------------------------|------------------------------|
|                                            |             |                                       | % Fibrous           | % Non-Fibrous                         | % Type                       |
| 10-6100-8B-Plaster<br>392500085-0020       |             | White<br>Non-Fibrous<br>Homogeneous   |                     | 37% Quartz<br>63% Non-fibrous (Other) | None Detected                |
| 10-6100-8B-Plaster<br>392500085-0020A      |             | Various<br>Non-Fibrous<br>Homogeneous |                     | 17% Quartz<br>83% Non-fibrous (Other) | None Detected                |
| 10-6100-8C-Plaster<br>392500085-0021       |             | White<br>Non-Fibrous<br>Homogeneous   |                     | 29% Quartz<br>71% Non-fibrous (Other) | None Detected                |
| 10-6100-8C-Plaster<br>392500085-0021A      |             | Various<br>Non-Fibrous<br>Homogeneous |                     | 12% Quartz<br>88% Non-fibrous (Other) | None Detected                |
| 10-6100-9A-Floor Tile<br>392500085-0022    |             | Tan<br>Non-Fibrous<br>Homogeneous     |                     | 95% Non-fibrous (Other)               | 5% Chrysotile                |
| 10-6100-9A-Mastic<br>392500085-0022A       |             | Tan<br>Non-Fibrous<br>Homogeneous     |                     | 100% Non-fibrous (Other)              | None Detected                |
| 10-6100-9A-Mastic<br>392500085-0022B       |             | Black<br>Non-Fibrous<br>Homogeneous   |                     | 92% Non-fibrous (Other)               | 8% Chrysotile                |
| 10-6100-9B-Floor Tile<br>392500085-0023    |             |                                       |                     |                                       | Positive Stop (Not Analyzed) |
| 10-6100-9B-Mastic<br>392500085-0023A       |             | Tan<br>Non-Fibrous<br>Homogeneous     |                     | 100% Non-fibrous (Other)              | None Detected                |
| 10-6100-9B-Mastic<br>392500085-0023B       |             |                                       |                     |                                       | Positive Stop (Not Analyzed) |
| 10-6100-9C-Floor Tile<br>392500085-0024    |             |                                       |                     |                                       | Positive Stop (Not Analyzed) |
| 10-6100-9C-Mastic<br>392500085-0024A       |             | Tan<br>Non-Fibrous<br>Homogeneous     |                     | 100% Non-fibrous (Other)              | None Detected                |
| 10-6100-9C-Mastic<br>392500085-0024B       |             |                                       |                     |                                       | Positive Stop (Not Analyzed) |
| 10-6100-10A-Cove<br>Base<br>392500085-0025 |             | Brown<br>Non-Fibrous<br>Homogeneous   |                     | 100% Non-fibrous (Other)              | None Detected                |
| 10-6100-10A-Mastic<br>392500085-0025A      |             | White<br>Non-Fibrous<br>Homogeneous   |                     | 100% Non-fibrous (Other)              | None Detected                |
| 10-6100-10B-Cove<br>Base<br>392500085-0026 |             | Brown<br>Non-Fibrous<br>Homogeneous   |                     | 100% Non-fibrous (Other)              | None Detected                |
| 10-6100-10B-Mastic<br>392500085-0026A      |             | White<br>Non-Fibrous<br>Homogeneous   |                     | 100% Non-fibrous (Other)              | None Detected                |
| 10-6100-10C-Cove<br>Base<br>392500085-0027 |             | Brown<br>Non-Fibrous<br>Homogeneous   |                     | 100% Non-fibrous (Other)              | None Detected                |

Initial report from: 01/17/2025 17:48:34



# EMSL Analytical, Inc.

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EMSL Order: 392500085

Customer ID: SC150

Customer PO:

Project ID:

## Test Report: Asbestos Analysis of Bulk Materials via AHERA Method 40CFR 763 Subpart E Appendix E supplemented with EPA 600/R-93/116 using Polarized Light Microscopy

| Sample                   | Description | Appearance                          | Non-Asbestos                   |                                        | Asbestos      |
|--------------------------|-------------|-------------------------------------|--------------------------------|----------------------------------------|---------------|
|                          |             |                                     | % Fibrous                      | % Non-Fibrous                          | % Type        |
| 10-6100-10C-Mastic       |             | White<br>Non-Fibrous<br>Homogeneous |                                | 100% Non-fibrous (Other)               | None Detected |
| 392500085-0027A          |             |                                     |                                |                                        |               |
| 10-6100-11A              |             | Gray<br>Non-Fibrous<br>Homogeneous  |                                | 100% Non-fibrous (Other)               | None Detected |
| 392500085-0028           |             |                                     |                                |                                        |               |
| 10-6100-11B              |             | Gray<br>Non-Fibrous<br>Homogeneous  |                                | 100% Non-fibrous (Other)               | None Detected |
| 392500085-0029           |             |                                     |                                |                                        |               |
| 10-6100-11C              |             | Gray<br>Non-Fibrous<br>Homogeneous  |                                | 100% Non-fibrous (Other)               | None Detected |
| 392500085-0030           |             |                                     |                                |                                        |               |
| 10-6100-12A              |             | Tan<br>Fibrous<br>Homogeneous       | 29% Cellulose<br>38% Min. Wool | 29% Perlite<br>4% Non-fibrous (Other)  | None Detected |
| 392500085-0031           |             |                                     |                                |                                        |               |
| 10-6100-12B              |             | Tan<br>Fibrous<br>Homogeneous       | 26% Cellulose<br>35% Min. Wool | 26% Perlite<br>13% Non-fibrous (Other) | None Detected |
| 392500085-0032           |             |                                     |                                |                                        |               |
| 10-6100-12C              |             | Tan<br>Fibrous<br>Homogeneous       | 30% Cellulose<br>37% Min. Wool | 22% Perlite<br>11% Non-fibrous (Other) | None Detected |
| 392500085-0033           |             |                                     |                                |                                        |               |
| 10-6100-13A              |             | White<br>Non-Fibrous<br>Homogeneous |                                | 37% Quartz<br>63% Non-fibrous (Other)  | None Detected |
| 392500085-0034           |             |                                     |                                |                                        |               |
| 10-6100-13B              |             | White<br>Non-Fibrous<br>Homogeneous |                                | 38% Quartz<br>62% Non-fibrous (Other)  | None Detected |
| 392500085-0035           |             |                                     |                                |                                        |               |
| 10-6100-13C              |             | White<br>Non-Fibrous<br>Homogeneous |                                | 32% Quartz<br>68% Non-fibrous (Other)  | None Detected |
| 392500085-0036           |             |                                     |                                |                                        |               |
| 10-6100-14A-Floor Tile   |             | White<br>Non-Fibrous<br>Homogeneous |                                | 100% Non-fibrous (Other)               | None Detected |
| 392500085-0037           |             |                                     |                                |                                        |               |
| 10-6100-14A-Mastic       |             | Tan<br>Non-Fibrous<br>Homogeneous   |                                | 100% Non-fibrous (Other)               | None Detected |
| 392500085-0037A          |             |                                     |                                |                                        |               |
| 10-6100-14B-Floor Tile   |             | White<br>Non-Fibrous<br>Homogeneous |                                | 100% Non-fibrous (Other)               | None Detected |
| 392500085-0038           |             |                                     |                                |                                        |               |
| 10-6100-14B-Mastic       |             | Tan<br>Non-Fibrous<br>Homogeneous   |                                | 100% Non-fibrous (Other)               | None Detected |
| 392500085-0038A          |             |                                     |                                |                                        |               |
| 10-6100-14C-Floor Tile   |             | White<br>Non-Fibrous<br>Homogeneous |                                | 100% Non-fibrous (Other)               | None Detected |
| 392500085-0039           |             |                                     |                                |                                        |               |
| 10-6100-14C-Mastic       |             | Tan<br>Non-Fibrous<br>Homogeneous   |                                | 100% Non-fibrous (Other)               | None Detected |
| 392500085-0039A          |             |                                     |                                |                                        |               |
| 10-6100-15A-Cove<br>Base |             | Tan<br>Non-Fibrous<br>Homogeneous   |                                | 100% Non-fibrous (Other)               | None Detected |
| 392500085-0040           |             |                                     |                                |                                        |               |
| 10-6100-15A-Mastic       |             | Tan<br>Non-Fibrous<br>Homogeneous   |                                | 100% Non-fibrous (Other)               | None Detected |
| 392500085-0040A          |             |                                     |                                |                                        |               |

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## Test Report: Asbestos Analysis of Bulk Materials via AHERA Method 40CFR 763 Subpart E Appendix E supplemented with EPA 600/R-93/116 using Polarized Light Microscopy

| Sample                   | Description | Appearance                             | <u>Non-Asbestos</u>        |                          | <u>Asbestos</u>              |
|--------------------------|-------------|----------------------------------------|----------------------------|--------------------------|------------------------------|
|                          |             |                                        | % Fibrous                  | % Non-Fibrous            | % Type                       |
| 10-6100-15B-Cove<br>Base |             | Tan<br>Non-Fibrous<br>Homogeneous      |                            | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0041           |             |                                        |                            |                          |                              |
| 10-6100-15B-Mastic       |             | Tan<br>Non-Fibrous<br>Homogeneous      |                            | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0041A          |             |                                        |                            |                          |                              |
| 10-6100-15C-Cove<br>Base |             | Tan<br>Non-Fibrous<br>Homogeneous      |                            | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0042           |             |                                        |                            |                          |                              |
| 10-6100-15C-Mastic       |             | Tan<br>Non-Fibrous<br>Homogeneous      |                            | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0042A          |             |                                        |                            |                          |                              |
| 10-6100-16A              |             | Black<br>Non-Fibrous<br>Homogeneous    |                            | 91% Non-fibrous (Other)  | 9% Chrysotile                |
| 392500085-0043           |             |                                        |                            |                          |                              |
| 10-6100-16B              |             |                                        |                            |                          | Positive Stop (Not Analyzed) |
| 392500085-0044           |             |                                        |                            |                          |                              |
| 10-6100-16C              |             |                                        |                            |                          | Positive Stop (Not Analyzed) |
| 392500085-0045           |             |                                        |                            |                          |                              |
| 10-6100-17A              |             | White<br>Non-Fibrous<br>Homogeneous    |                            | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0046           |             |                                        |                            |                          |                              |
| 10-6100-17B              |             | White<br>Non-Fibrous<br>Homogeneous    |                            | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0047           |             |                                        |                            |                          |                              |
| 10-6100-17C              |             | White<br>Non-Fibrous<br>Homogeneous    |                            | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0048           |             |                                        |                            |                          |                              |
| 10-6100-18A-Wrap         |             | Silver<br>Fibrous<br>Heterogeneous     | 36% Cellulose<br>16% Glass | 48% Non-fibrous (Other)  | None Detected                |
| 392500085-0049           |             |                                        |                            |                          |                              |
| 10-6100-18A-Adhesive     |             | Tan<br>Non-Fibrous<br>Homogeneous      |                            | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0049A          |             |                                        |                            |                          |                              |
| 10-6100-18B-Wrap         |             | Silver<br>Fibrous<br>Heterogeneous     | 37% Cellulose<br>17% Glass | 46% Non-fibrous (Other)  | None Detected                |
| 392500085-0050           |             |                                        |                            |                          |                              |
| 10-6100-18B-Adhesive     |             | Tan<br>Non-Fibrous<br>Homogeneous      |                            | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0050A          |             |                                        |                            |                          |                              |
| 10-6100-18C-Wrap         |             | Silver<br>Non-Fibrous<br>Heterogeneous | 34% Cellulose<br>6% Glass  | 60% Non-fibrous (Other)  | None Detected                |
| 392500085-0051           |             |                                        |                            |                          |                              |
| 10-6100-18C-Adhesive     |             | Tan<br>Non-Fibrous<br>Homogeneous      |                            | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0051A          |             |                                        |                            |                          |                              |
| 10-6100-19A              |             | White<br>Non-Fibrous<br>Homogeneous    |                            | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0052           |             |                                        |                            |                          |                              |
| 10-6100-19B              |             | White<br>Non-Fibrous<br>Homogeneous    |                            | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0053           |             |                                        |                            |                          |                              |

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## Test Report: Asbestos Analysis of Bulk Materials via AHERA Method 40CFR 763 Subpart E Appendix E supplemented with EPA 600/R-93/116 using Polarized Light Microscopy

| Sample                     | Description | Appearance                              | Non-Asbestos                     |                          | Asbestos      |
|----------------------------|-------------|-----------------------------------------|----------------------------------|--------------------------|---------------|
|                            |             |                                         | % Fibrous                        | % Non-Fibrous            | % Type        |
| 10-6100-19C                |             | White<br>Non-Fibrous<br>Homogeneous     |                                  | 100% Non-fibrous (Other) | None Detected |
| 392500085-0054             |             |                                         |                                  |                          |               |
| 10-6100-20-Rubber Membrane |             | Black<br>Non-Fibrous<br>Homogeneous     |                                  | 100% Non-fibrous (Other) | None Detected |
| 392500085-0055             |             |                                         |                                  |                          |               |
| 10-6100-20-Adhesive        |             | Gray<br>Non-Fibrous<br>Homogeneous      |                                  | 100% Non-fibrous (Other) | None Detected |
| 392500085-0055A            |             |                                         |                                  |                          |               |
| 10-6100-20-Insulation      |             | Various<br>Non-Fibrous<br>Heterogeneous | 5% Cellulose<br>3% Glass         | 92% Non-fibrous (Other)  | None Detected |
| 392500085-0055B            |             |                                         |                                  |                          |               |
| 10-6100-20-Insulation      |             | White<br>Non-Fibrous<br>Homogeneous     | 18% Glass                        | 82% Non-fibrous (Other)  | None Detected |
| 392500085-0055C            |             |                                         |                                  |                          |               |
| 10-6100-21A                |             | White<br>Non-Fibrous<br>Homogeneous     |                                  | 100% Non-fibrous (Other) | None Detected |
| 392500085-0056             |             |                                         |                                  |                          |               |
| 10-6100-21B                |             | White<br>Non-Fibrous<br>Homogeneous     |                                  | 100% Non-fibrous (Other) | None Detected |
| 392500085-0057             |             |                                         |                                  |                          |               |
| 10-6100-21C                |             | White<br>Non-Fibrous<br>Homogeneous     |                                  | 100% Non-fibrous (Other) | None Detected |
| 392500085-0058             |             |                                         |                                  |                          |               |
| 10-6100-22A                |             | Gray<br>Non-Fibrous<br>Homogeneous      |                                  | 100% Non-fibrous (Other) | None Detected |
| 392500085-0059             |             |                                         |                                  |                          |               |
| 10-6100-22B                |             | Gray<br>Non-Fibrous<br>Homogeneous      |                                  | 100% Non-fibrous (Other) | None Detected |
| 392500085-0060             |             |                                         |                                  |                          |               |
| 10-6100-22C                |             | Gray<br>Non-Fibrous<br>Homogeneous      |                                  | 100% Non-fibrous (Other) | None Detected |
| 392500085-0061             |             |                                         |                                  |                          |               |
| 10-6100-23A-Wrap           |             | Silver<br>Fibrous<br>Heterogeneous      | 39% Cellulose<br>19% Glass       | 42% Non-fibrous (Other)  | None Detected |
| 392500085-0062             |             |                                         |                                  |                          |               |
| 10-6100-23A-Adhesive       |             | Tan<br>Non-Fibrous<br>Homogeneous       |                                  | 100% Non-fibrous (Other) | None Detected |
| 392500085-0062A            |             |                                         |                                  |                          |               |
| 10-6100-23B-Wrap           |             | Silver<br>Fibrous<br>Heterogeneous      | 36% Cellulose<br>16% Glass       | 48% Non-fibrous (Other)  | None Detected |
| 392500085-0063             |             |                                         |                                  |                          |               |
| 10-6100-23B-Adhesive       |             | Tan<br>Non-Fibrous<br>Homogeneous       |                                  | 100% Non-fibrous (Other) | None Detected |
| 392500085-0063A            |             |                                         |                                  |                          |               |
| 10-6100-23C-Wrap           |             | Silver<br>Fibrous<br>Heterogeneous      | 40% Cellulose<br>12% Glass       | 48% Non-fibrous (Other)  | None Detected |
| 392500085-0064             |             |                                         |                                  |                          |               |
| 10-6100-23C-Adhesive       |             | Tan<br>Non-Fibrous<br>Homogeneous       |                                  | 100% Non-fibrous (Other) | None Detected |
| 392500085-0064A            |             |                                         |                                  |                          |               |
| 10-6100-24-Wrap            |             | Gray<br>Fibrous<br>Homogeneous          | 97% Fibrous (Other)              | 3% Non-fibrous (Other)   | None Detected |
| 392500085-0065             |             |                                         |                                  |                          |               |
| 10-6100-24-Insulation      |             | Gray<br>Non-Fibrous<br>Homogeneous      | 37% Min. Wool<br>4% Wollastonite | 59% Non-fibrous (Other)  | None Detected |
| 392500085-0065A            |             |                                         |                                  |                          |               |

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## Test Report: Asbestos Analysis of Bulk Materials via AHERA Method 40CFR 763 Subpart E Appendix E supplemented with EPA 600/R-93/116 using Polarized Light Microscopy

| Sample                                     | Description | Appearance                          | <u>Non-Asbestos</u> |                          | <u>Asbestos</u> |
|--------------------------------------------|-------------|-------------------------------------|---------------------|--------------------------|-----------------|
|                                            |             |                                     | % Fibrous           | % Non-Fibrous            | % Type          |
| 10-6100-25A<br>392500085-0066              |             | Brown<br>Non-Fibrous<br>Homogeneous |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-25B<br>392500085-0067              |             | Brown<br>Non-Fibrous<br>Homogeneous |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-25C<br>392500085-0068              |             | Brown<br>Non-Fibrous<br>Homogeneous |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-26A<br>392500085-0069              |             | Black<br>Non-Fibrous<br>Homogeneous | 5% Fibrous (Other)  | 95% Non-fibrous (Other)  | None Detected   |
| 10-6100-26B<br>392500085-0070              |             | Black<br>Non-Fibrous<br>Homogeneous | 6% Fibrous (Other)  | 94% Non-fibrous (Other)  | None Detected   |
| 10-6100-26C<br>392500085-0071              |             | Black<br>Non-Fibrous<br>Homogeneous |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-28A<br>392500085-0072              |             | White<br>Non-Fibrous<br>Homogeneous |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-28B<br>392500085-0073              |             | White<br>Non-Fibrous<br>Homogeneous |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-28C<br>392500085-0074              |             | White<br>Non-Fibrous<br>Homogeneous |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-30A<br>392500085-0075              |             | Tan<br>Non-Fibrous<br>Homogeneous   |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-30B<br>392500085-0076              |             | Tan<br>Non-Fibrous<br>Homogeneous   |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-30C<br>392500085-0077              |             | White<br>Non-Fibrous<br>Homogeneous |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-31A-Floor Tile<br>392500085-0078   |             | White<br>Non-Fibrous<br>Homogeneous |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-31A-Mastic<br>392500085-0078A      |             | Tan<br>Non-Fibrous<br>Homogeneous   |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-31B-Floor Tile<br>392500085-0079   |             | White<br>Non-Fibrous<br>Homogeneous |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-31B-Mastic<br>392500085-0079A      |             | Tan<br>Non-Fibrous<br>Homogeneous   |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-31C-Floor Tile<br>392500085-0080   |             | White<br>Non-Fibrous<br>Homogeneous |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-31C-Mastic<br>392500085-0080A      |             | Tan<br>Non-Fibrous<br>Homogeneous   |                     | 100% Non-fibrous (Other) | None Detected   |
| 10-6100-32A-Cove<br>Base<br>392500085-0081 |             | Brown<br>Non-Fibrous<br>Homogeneous |                     | 100% Non-fibrous (Other) | None Detected   |

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| Sample                 | Description | Appearance                 | Non-Asbestos  |                                        | Asbestos                     |
|------------------------|-------------|----------------------------|---------------|----------------------------------------|------------------------------|
|                        |             |                            | % Fibrous     | % Non-Fibrous                          | % Type                       |
| 10-6100-32A-Mastic     |             | Yellow                     |               | 100% Non-fibrous (Other)               | None Detected                |
| 392500085-0081A        |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-32B-Cove Base  |             | Brown                      |               | 100% Non-fibrous (Other)               | None Detected                |
| 392500085-0082         |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-32B-Mastic     |             | Yellow                     |               | 100% Non-fibrous (Other)               | None Detected                |
| 392500085-0082A        |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-32C-Cove Base  |             | Brown                      |               | 100% Non-fibrous (Other)               | None Detected                |
| 392500085-0083         |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-32C-Mastic     |             | Yellow                     |               | 100% Non-fibrous (Other)               | None Detected                |
| 392500085-0083A        |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-33A            |             | White                      |               | 100% Non-fibrous (Other)               | None Detected                |
| 392500085-0084         |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-33B            |             | White                      |               | 100% Non-fibrous (Other)               | None Detected                |
| 392500085-0085         |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-33C            |             | White                      |               | 100% Non-fibrous (Other)               | None Detected                |
| 392500085-0086         |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-34A            |             | Gray                       |               | 36% Perlite<br>61% Non-fibrous (Other) | 3% Chrysotile                |
| 392500085-0087         |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-34B            |             |                            |               |                                        | Positive Stop (Not Analyzed) |
| 392500085-0088         |             |                            |               |                                        |                              |
| 10-6100-34C            |             |                            |               |                                        | Positive Stop (Not Analyzed) |
| 392500085-0089         |             |                            |               |                                        |                              |
| 10-6100-35A-Floor Tile |             | White                      |               | 100% Non-fibrous (Other)               | None Detected                |
| 392500085-0090         |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-35A-Grout      |             | Tan                        |               | 100% Non-fibrous (Other)               | None Detected                |
| 392500085-0090A        |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-35B-Floor Tile |             | White                      |               | 100% Non-fibrous (Other)               | None Detected                |
| 392500085-0091         |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-35B-Grout      |             | Tan                        |               | 100% Non-fibrous (Other)               | None Detected                |
| 392500085-0091A        |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-35C-Floor Tile |             | White                      |               | 100% Non-fibrous (Other)               | None Detected                |
| 392500085-0092         |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-35C-Grout      |             | Tan                        |               | 100% Non-fibrous (Other)               | None Detected                |
| 392500085-0092A        |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |
| 10-6100-36A            |             | White                      | 47% Min. Wool | 53% Non-fibrous (Other)                | None Detected                |
| 392500085-0093         |             | Non-Fibrous<br>Homogeneous |               |                                        |                              |

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| Sample                 | Description | Appearance                 | Non-Asbestos  |                          | Asbestos                     |
|------------------------|-------------|----------------------------|---------------|--------------------------|------------------------------|
|                        |             |                            | % Fibrous     | % Non-Fibrous            | % Type                       |
| 10-6100-36B            |             | White                      | 48% Min. Wool | 52% Non-fibrous (Other)  | None Detected                |
| 392500085-0094         |             | Non-Fibrous<br>Homogeneous |               |                          |                              |
| 10-6100-36C            |             | White                      | 44% Min. Wool | 56% Non-fibrous (Other)  | None Detected                |
| 392500085-0095         |             | Non-Fibrous<br>Homogeneous |               |                          |                              |
| 10-6100-37A            |             | White                      |               | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0096         |             | Non-Fibrous<br>Homogeneous |               |                          |                              |
| 10-6100-37B            |             | White                      |               | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0097         |             | Non-Fibrous<br>Homogeneous |               |                          |                              |
| 10-6100-37C            |             | White                      |               | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0098         |             | Non-Fibrous<br>Homogeneous |               |                          |                              |
| 10-6100-38A-Floor Tile |             | Tan                        |               | 94% Non-fibrous (Other)  | 6% Chrysotile                |
| 392500085-0099         |             | Non-Fibrous<br>Homogeneous |               |                          |                              |
| 10-6100-38A-Mastic     |             | Black                      |               | 91% Non-fibrous (Other)  | 9% Chrysotile                |
| 392500085-0099A        |             | Non-Fibrous<br>Homogeneous |               |                          |                              |
| 10-6100-38B-Floor Tile |             |                            |               |                          | Positive Stop (Not Analyzed) |
| 392500085-0100         |             |                            |               |                          |                              |
| 10-6100-38B-Mastic     |             |                            |               |                          | Positive Stop (Not Analyzed) |
| 392500085-0100A        |             |                            |               |                          |                              |
| 10-6100-38C-Floor Tile |             |                            |               |                          | Positive Stop (Not Analyzed) |
| 392500085-0101         |             |                            |               |                          |                              |
| 10-6100-38C-Mastic     |             |                            |               |                          | Positive Stop (Not Analyzed) |
| 392500085-0101A        |             |                            |               |                          |                              |
| 10-6100-39A-Floor Tile |             | Gray                       |               | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0102         |             | Non-Fibrous<br>Homogeneous |               |                          |                              |
| 10-6100-39A-Mastic     |             | Tan                        |               | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0102A        |             | Non-Fibrous<br>Homogeneous |               |                          |                              |
| 10-6100-39A-Mastic     |             | Black                      |               | 94% Non-fibrous (Other)  | 6% Chrysotile                |
| 392500085-0102B        |             | Non-Fibrous<br>Homogeneous |               |                          |                              |
| 10-6100-39B-Floor Tile |             | Gray                       |               | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0103         |             | Non-Fibrous<br>Homogeneous |               |                          |                              |
| 10-6100-39B-Mastic     |             | Tan                        |               | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0103A        |             | Non-Fibrous<br>Homogeneous |               |                          |                              |
| 10-6100-39B-Mastic     |             |                            |               |                          | Positive Stop (Not Analyzed) |
| 392500085-0103B        |             |                            |               |                          |                              |
| 10-6100-39C-Floor Tile |             | Gray                       |               | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0104         |             | Non-Fibrous<br>Homogeneous |               |                          |                              |
| 10-6100-39C-Mastic     |             | Tan                        |               | 100% Non-fibrous (Other) | None Detected                |
| 392500085-0104A        |             | Non-Fibrous<br>Homogeneous |               |                          |                              |

Initial report from: 01/17/2025 17:48:34



# EMSL Analytical, Inc.

100 Green Park Industrial Court Saint Louis, MO 63123

Tel/Fax: (314) 577-0150 / (314) 776-3313

<http://www.EMSL.com> / [saintlouislab@emsl.com](mailto:saintlouislab@emsl.com)

EMSL Order: 392500085

Customer ID: SC150

Customer PO:

Project ID:

## Test Report: Asbestos Analysis of Bulk Materials via AHERA Method 40CFR 763 Subpart E Appendix E supplemented with EPA 600/R-93/116 using Polarized Light Microscopy

| Sample                 | Description | Appearance                          | Non-Asbestos |                          | Asbestos                     |
|------------------------|-------------|-------------------------------------|--------------|--------------------------|------------------------------|
|                        |             |                                     | % Fibrous    | % Non-Fibrous            | % Type                       |
| 10-6100-39C-Mastic     |             |                                     |              |                          | Positive Stop (Not Analyzed) |
| <i>392500085-0104B</i> |             |                                     |              |                          |                              |
| 10-6100-40A            |             | Brown<br>Non-Fibrous<br>Homogeneous |              | 100% Non-fibrous (Other) | None Detected                |
| <i>392500085-0105</i>  |             |                                     |              |                          |                              |
| 10-6100-40B            |             | Brown<br>Non-Fibrous<br>Homogeneous |              | 100% Non-fibrous (Other) | None Detected                |
| <i>392500085-0106</i>  |             |                                     |              |                          |                              |
| 10-6100-40C            |             | Brown<br>Non-Fibrous<br>Homogeneous |              | 100% Non-fibrous (Other) | None Detected                |
| <i>392500085-0107</i>  |             |                                     |              |                          |                              |
| 10-6100-41A            |             | Tan<br>Non-Fibrous<br>Homogeneous   |              | 100% Non-fibrous (Other) | None Detected                |
| <i>392500085-0108</i>  |             |                                     |              |                          |                              |
| 10-6100-41B            |             | Tan<br>Non-Fibrous<br>Homogeneous   |              | 100% Non-fibrous (Other) | None Detected                |
| <i>392500085-0109</i>  |             |                                     |              |                          |                              |
| 10-6100-41C            |             | Tan<br>Non-Fibrous<br>Homogeneous   |              | 100% Non-fibrous (Other) | None Detected                |
| <i>392500085-0110</i>  |             |                                     |              |                          |                              |

Analyst(s)

Oliver Malone (48)

Sue Ferrario (109)

Jeff Siria, Laboratory Manager  
or Other Approved Signatory

EMSL maintains liability limited to cost of analysis. Interpretation and use of test results are the responsibility of the client. This report relates only to the samples reported above, and may not be reproduced, except in full, without written approval by EMSL. EMSL bears no responsibility for sample collection activities or analytical method limitations. The report reflects the samples as received. Results are generated from the field sampling data (sampling volumes and areas, locations, etc.) provided by the client on the Chain of Custody. Samples are within quality control criteria and met method specifications unless otherwise noted. The above analyses were performed in general compliance with Appendix E to Subpart E of 40 CFR (previously EPA 600/M4-82-020 "Interim Method") but augmented with procedures outlined in the 1993 ("final") version of the method. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST or any agency of the federal government. Non-friable organically bound materials present a problem matrix and therefore EMSL recommends gravimetric reduction prior to analysis. Unless requested by the client, building materials manufactured with multiple layers (i.e. linoleum, wallboard, etc.) are reported as a single sample. Estimation of uncertainty is available on request.

Samples analyzed by EMSL Analytical, Inc. Saint Louis, MO NVLAP Lab Code 200742-0, CA 2668, OR 4194-001

Initial report from: 01/17/2025 17:48:34

392500085



# BULK ASBESTOS CHAIN OF CUSTODY

130 Point West Boulevard  
St. Charles, Missouri 63301  
636-949-8200 Fax 636-949-8269  
www.sciengineering.com

| Company: SCI Engineering, Inc.                                                                                                                |                                                                          |                                      | Please Provide Results Via: <input type="checkbox"/> Fax <input type="checkbox"/> Email <input checked="" type="checkbox"/> Mail           |                                  |                                                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|-------------------------------------------------|
| Street: 130 Point West Boulevard                                                                                                              |                                                                          |                                      | To: Dan Vielweber                                                                                                                          |                                  |                                                 |
| City/State/Zip: St. Charles, Missouri 63301                                                                                                   |                                                                          |                                      | Telephone #: 618-779-7910 Fax #: 636-949-8269                                                                                              |                                  |                                                 |
| Project Name: MO State Highway Patrol HQ                                                                                                      |                                                                          |                                      | Email: dvielweber@sciengineering.com                                                                                                       |                                  |                                                 |
| Project Number: 2010-6100.20                                                                                                                  |                                                                          |                                      |                                                                                                                                            |                                  |                                                 |
| Turnaround Time (TAT) Options - Please Check One                                                                                              |                                                                          |                                      |                                                                                                                                            |                                  |                                                 |
| <input type="checkbox"/> 3 Hour                                                                                                               | <input type="checkbox"/> 6 Hour                                          | <input type="checkbox"/> 24 Hour     | <input type="checkbox"/> 48 Hour                                                                                                           | <input type="checkbox"/> 72 Hour | <input type="checkbox"/> 96 Hour                |
|                                                                                                                                               |                                                                          |                                      |                                                                                                                                            |                                  | <input checked="" type="checkbox"/> Other 5 Day |
| PLM Bulk Analysis                                                                                                                             |                                                                          |                                      | TEM Bulk Analysis                                                                                                                          |                                  |                                                 |
| <input checked="" type="checkbox"/> PLM-EPA 600<br><input type="checkbox"/> PLM-EPA 600 NOB<br><input type="checkbox"/> PLM-Point Count       |                                                                          |                                      | <input type="checkbox"/> TEM EPA NOB - EPA 600/R-93/116 Section 2.5.5.1<br><input type="checkbox"/> Chatfield Protocol (semi-quantitative) |                                  |                                                 |
| <input checked="" type="checkbox"/> Check Box for Stop Positive                                                                               |                                                                          |                                      |                                                                                                                                            |                                  |                                                 |
| Comments: Material Location Codes - (1)-Academy Bldg. (2)-Dorm Bldg. (3)-PT Bldg. Note: Unable to Access Much of Roof as it was Snow Covered. |                                                                          |                                      |                                                                                                                                            |                                  |                                                 |
| Samplers Name: Kieran Kleinhenz                                                                                                               |                                                                          |                                      | Samplers Signature: <i>[Signature]</i>                                                                                                     |                                  | Date Sampled: 01/09/24                          |
| Building Use/Description/Features: Classroom+Admin Bldg/Dorm Bldg/Physical Training Bldg                                                      |                                                                          |                                      | Age:                                                                                                                                       |                                  | Size:                                           |
| Windows: Metal                                                                                                                                | Siding: Brick/Plaster                                                    | Roof: Flat Membrane                  | Attic: Fiberglass                                                                                                                          |                                  | HVAC: Boiler                                    |
| Sample #                                                                                                                                      | Material Location                                                        | Material Description                 | Approx. Quantity                                                                                                                           | Condition                        | Comments                                        |
| 10-6100-1ABC                                                                                                                                  | (1)-Throughout. (2)-2nd Fl Throughout                                    | 4" Dark Brown CB                     |                                                                                                                                            | Good                             | w Tan Mastic                                    |
| VOID                                                                                                                                          | -                                                                        | -                                    | -                                                                                                                                          | -                                | Sample Not Needed                               |
| 10-6100-3ABC                                                                                                                                  | (1)-Office/Lobby Area                                                    | 2x2 Pinhole Wormtrack CT             |                                                                                                                                            | Good                             |                                                 |
| 10-6100-4ABC                                                                                                                                  | (1)-Atrium Areas                                                         | 1x1 Pinhole CT w Yellow Mastic Pucks | 100sf                                                                                                                                      | Good                             | Mastic Puck Samples in Separate Baggie          |
| 10-6100-5ABC                                                                                                                                  | Throughout Complex                                                       | Brown Stair Tread w Brown Mastic     |                                                                                                                                            | Good                             |                                                 |
| 10-6100-6ABC                                                                                                                                  | (1)-Throughout (2)-1st fl Offices, 2nd/3rd Fl Throughout                 | Grey 4" CB                           |                                                                                                                                            | Good                             | w Tan Mastic                                    |
| 10-6100-7ABC                                                                                                                                  | Common Bathrooms                                                         | Bathroom Caulk                       | 240lf                                                                                                                                      | Good                             | On Sinks, Toilets, Urinals                      |
| 10-6100-8ABC                                                                                                                                  | Throughout Complex                                                       | Plaster Board Wall System            |                                                                                                                                            | Good                             |                                                 |
| 10-6100-9ABC                                                                                                                                  | (1)-Classrooms B.G.D.E. Hallways, Mech/Elec Rooms, Kitchen, Media Office | 12x12 Tan w Brown Mottle FT          | 10,100sf                                                                                                                                   | Good                             | w Black Mastic, On Conc                         |
| Relinquished: <i>[Signature]</i>                                                                                                              |                                                                          |                                      | Date: 1/10/25                                                                                                                              |                                  | Time: 20:00                                     |
| Received: VM JAN 13 2025                                                                                                                      |                                                                          |                                      | Date:                                                                                                                                      |                                  | Time: 8:00 D                                    |

392500085

## Project Name/Number

| Sample #      | Material Location                                    | Material Description                              | Approx. Quantity | Condition | Comments                |
|---------------|------------------------------------------------------|---------------------------------------------------|------------------|-----------|-------------------------|
| 10-6100-10ABC | Throughout Complex                                   | Light Brown 4" CB                                 |                  | Good      | w White Mastic          |
| 10-6100-11ABC | (1+2+3)-On all Doors and Windows (Int+Ext)           | Grey Door/Window Caulk                            | 4000lf           | Good      |                         |
| 10-6100-12ABC | Throughout Complex                                   | 2x4 Pinhole WT CT                                 |                  | Good      |                         |
| 10-6100-13ABC | Throughout Complex on Most Walls                     | Wall Texture                                      |                  | Good      |                         |
| 10-6100-14ABC | (1)-Class E, Kit Off, Multimedia Hallway             | 12x12 White Replacement FT                        | 220sf            | Good      | w Tan Mastic, on Conc   |
| 10-6100-15ABC | Throughout Complex                                   | Tan 4" CB                                         |                  | Good      | w Tan Mastic            |
| 10-6100-16ABC | (1)-Kitchen                                          | Black Sink Coating                                | 18sf             | Good      | On 6 sinks (not all)    |
| 10-6100-17ABC | (1) - Throughout                                     | Expansion Joint Caulk Between Plaster & CMU Walls | 50lf             | Good      |                         |
| 10-6100-18ABC | Throughout Complex                                   | Duct Tape                                         | 500sf            | Good      |                         |
| 10-6100-19ABC | Kitchen                                              | Wall Ceramic Tile Repair Caulk                    | 110lf            | Good      |                         |
| 10-6100-20    | Academy Bldg                                         | Roof Core                                         | -                | Good      |                         |
| 10-6100-21ABC | Lower Roof/Upper Roof Upper Layer Flashing           | White Flashing Sealant Caulk                      | 1100lf           | Good      |                         |
| 10-6100-22ABC | Upper Roof Lower Layer Flashing                      | Grey Flashing Sealant Caulk                       | 460lf            | Good      |                         |
| 10-6100-23ABC | Throughout Complex                                   | Pipe Insulation Wrap                              | 5000sf           | Good      |                         |
| 10-6100-24ABC | Throughout Complex                                   | Mudded Fittings                                   | 25x              | Good      | See Notes For Locations |
| 10-6100-25ABC | (2)-Boiler Room                                      | Foam/Fiberglass CT Mastic Pucks Brown             | 100sf            | Good      |                         |
| 10-6100-26ABC | (2)-Boiler Room                                      | Foam/Fiberglass CT Mastic Pucks Black             | 100sf            | Good      |                         |
| VOID          | -                                                    | -                                                 | -                | -         | Duplicate Sample        |
| 10-6100-28ABC | (2)-Boiler Room                                      | Boiler Expansion Tank Wrap White                  | 40sf             | Good      |                         |
| VOID          | -                                                    | -                                                 | -                | -         | Duplicate Sample        |
| 10-6100-30ABC | (2)-Boiler Room, on Boiler Circulation Pump Line Ins | Pinkish Tan Sealant Caulk                         | 15lf             | Good      |                         |



392500085

## Project Name/Number \_\_\_\_\_

| Sample #      | Material Location                     | Material Description          | Approx. Quantity | Condition | Comments                          |
|---------------|---------------------------------------|-------------------------------|------------------|-----------|-----------------------------------|
| 10-6100-31ABC | (2)-1st Floor Throughout              | 12x12 White w White Mottle FT | 3,400sf          | Good      | w Tan Mastic, on Conc             |
| 10-6100-32ABC | (1)-Lobby Area (2)-1st Floor          | Dark Brown 6' CB              |                  | Good      | w Yellow Mastic                   |
| 10-6100-33ABC | (2)-Windows Int                       | White Int Window Caulk        | 320lf            | Good      | Only on Bottom of All Windows     |
| 10-6100-34ABC | (2)-1st/2nd Floor Hall/Rooms          | Thinner Layer Popcorn Ceiling | 10,500sf         | Good      |                                   |
| 10-6100-35ABC | (2)-2nd Fl Hall Hall                  | White Terrazo FT              | 1000sf           | Good      | On Conc                           |
| 10-6100-36ABC | (2)-3rd Floor Hall/Rooms              | Thicker Layer Popcorn Ceiling | 8,100sf          | Good      |                                   |
| 10-6100-37ABC | (2)-Throughout in Dorm Room Bathrooms | White Sealant Caulk           | 3000sf           | Good      | On Sink/Shower/Toilet/Soap Holder |
| 10-6100-38ABC | (3)-Gym Floor, Basement Hall          | 12x12 White w Tan Mottle FT   | 10,500sf         | Good      | W Black Mastic, on Conc.          |
| 10-6100-39ABC | (3)-Shooting Range Area, Lower Level  | 12x12 Grey Mottle FT          | 1500sf           | Good      | W Black Mastic, on Conc.          |
| 10-6100-40ABC | Ext of Dorm Bldg                      | Brown Surfacing Plaster       | 7,000sf          | Good      |                                   |
| 10-6100-41ABC | Ext of All Bldgs                      | Tan Surfacing Texture         | 15,000sf         | Good      |                                   |
|               |                                       |                               |                  |           |                                   |
|               |                                       |                               |                  |           |                                   |
|               |                                       |                               |                  |           |                                   |
|               |                                       |                               |                  |           |                                   |
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|               |                                       |                               |                  |           |                                   |
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|               |                                       |                               |                  |           |                                   |
|               |                                       |                               |                  |           |                                   |
|               |                                       |                               |                  |           |                                   |
|               |                                       |                               |                  |           |                                   |
|               |                                       |                               |                  |           |                                   |
|               |                                       |                               |                  |           |                                   |
|               |                                       |                               |                  |           |                                   |

## Matkovic, Vanja

---

**From:** Dan Vielweber <DVielweber@sciengineering.com>  
**Sent:** Monday, January 13, 2025 11:36 AM  
**To:** Matkovic, Vanja  
**Cc:** Kuper, Sarah  
**Subject:** Re: MO State Highway Patrol HQ

### [EXTERNAL E-MAIL]

There is only one sample for 24. No A B C

Sent from my Verizon, Samsung Galaxy smartphone  
Get [Outlook for Android](#)

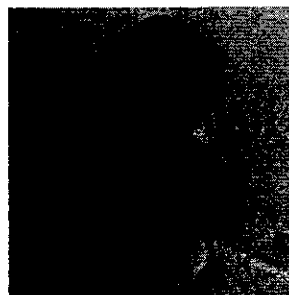


**Dan Vielweber**  
Staff Scientist

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**SCI ENGINEERING, INC.**

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This electronic communication and its attachments may contain confidential information. They are forwarded to you without passing through our standard review process. Design data and recommendations included herein should not be used for final design. If you have received this information in error, please notify the sender immediately.

---

**From:** Matkovic, Vanja <[vmatkovic@EMSL.com](mailto:vmatkovic@EMSL.com)>  
**Sent:** Monday, January 13, 2025 10:35:59 AM  
**To:** Dan Vielweber <[DVielweber@sciengineering.com](mailto:DVielweber@sciengineering.com)>  
**Cc:** Kuper, Sarah <[skuper@EMSL.com](mailto:skuper@EMSL.com)>  
**Subject:** MO State Highway Patrol HQ

You don't often get email from [vmatkovic@emsl.com](mailto:vmatkovic@emsl.com). [Learn why this is important](#)

Good morning,

We received your samples, but sample 24 is not matching. We have only one sample and is not labeled A,B or C. I am not sure if COC is not correct, or we are missing 2 samples.

Please let us know. Your samples will be on hold until we hear from you.

Thanks,

CERTIFICATION NUMBER:

**7011082924MOIR23121**

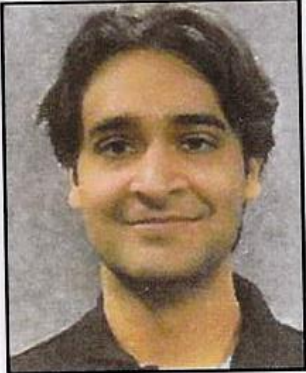
THIS CERTIFIES

**Kieran Kleinhenz**

HAS COMPLETED THE CERTIFICATION

REQUIREMENTS FOR

**Inspector**



APPROVED: **09/10/2024**

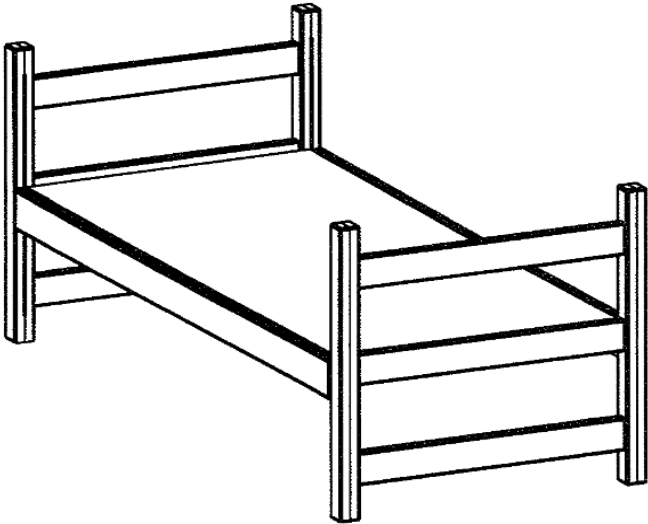
EXPIRES: **09/10/2025**

TRAINING DATE: **08/29/2024**

A handwritten signature in dark ink, appearing to read "Stephen M. Hall". The signature is fluid and cursive.

Director of Air Pollution Control Program

Missouri State Highway Patrol  
Dormitory Renovation

|                 |                                                                                                                                         |                                                     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| Tag:            | BD-1                                                                                                                                    |                                                     |
| Product:        | Single Bed                                                                                                                              | Qty: 126                                            |
| Manufacturer:   | MVE (Basis-of-Design)                                                                                                                   | Lead Time: Weeks<br>Warranty: Years                 |
|                 | Location:                                                                                                                               | Rooms:<br>Refer to Furniture Plans<br>for Locations |
| Description:    | Single XL Twin Bed, Bed end and side rails made from oak,<br>inside support & slats made from poplar<br>Dimensions: 38"W x 86"L x 36" H |                                                     |
| Finish/Color:   | Oak/Poplar Wood; Stain: Dark Oak                                                                                                        |                                                     |
| Options:        | Can accommodate Dormitory Twin (XL) mattresses                                                                                          |                                                     |
| Responsibility: | Owner provided, Contractor installed                                                                                                    |                                                     |
| Image:          |                                                     |                                                     |

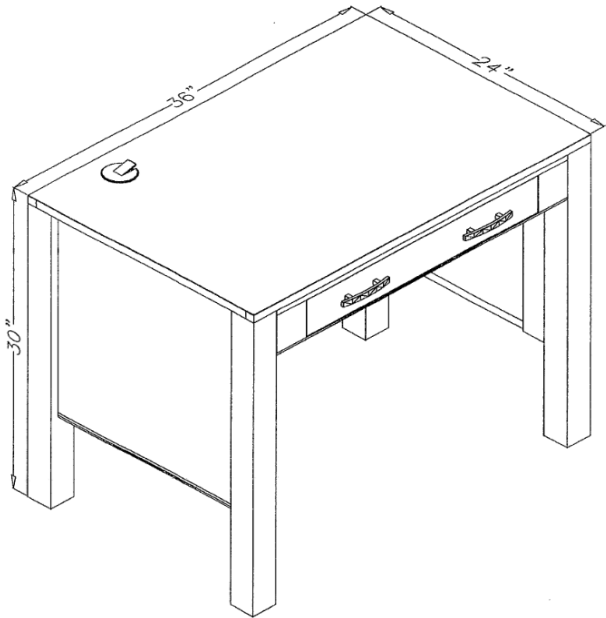
Missouri State Highway Patrol  
Dormitory Renovation

|                 |                                                                                                                                     |                                                     |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| Tag:            | CHR-1                                                                                                                               |                                                     |
| Product:        | Navigator Nesting Chair without Arms                                                                                                | Qty: 160                                            |
| Manufacturer:   | MVE (Basis-of-Design)                                                                                                               | Lead Time: Weeks<br>Warranty: Years                 |
|                 | Location:                                                                                                                           | Rooms:<br>Refer to Furniture Plans<br>for Locations |
| Description:    | Nesting chair without arms, Upholstered seat and dimpled polypropylene back<br>Seat: 18"H x 17.25"W x 18.5"D, Back: 14"H x 18.25" W |                                                     |
| Finish/Color:   | Foundation 10 Navy Upholstery                                                                                                       |                                                     |
| Options:        | Optional arms                                                                                                                       |                                                     |
| Responsibility: | Owner provided, Contractor installed                                                                                                |                                                     |
| Image:          |                                                  |                                                     |

Missouri State Highway Patrol  
Dormitory Renovation

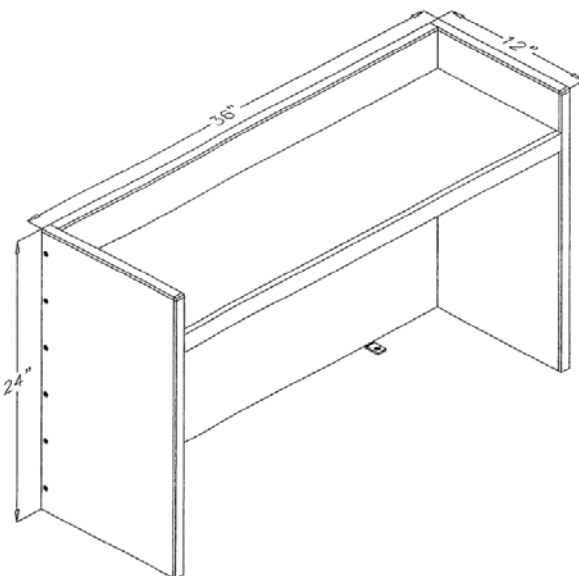
|                        |                                                                                      |                                                            |
|------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------|
| <b>Tag:</b>            | <b>CHR-2</b>                                                                         |                                                            |
| <b>Product:</b>        | Suave Chair                                                                          | <b>Qty:</b> 62                                             |
| <b>Manufacturer:</b>   | MVE (Basis-of-Design)                                                                | <b>Lead Time:</b> Weeks<br><b>Warranty:</b> Years          |
|                        | <b>Location:</b>                                                                     | <b>Rooms:</b><br>Refer to Furniture Plans<br>for Locations |
| <b>Description:</b>    | Fully upholstered lounge chair<br><br>Dimensions: 32"W x 28.25"H x 33.5"D            |                                                            |
| <b>Finish/Color:</b>   | Duraweave 10, Indigo                                                                 |                                                            |
| <b>Options:</b>        | Silver post legs or wooden legs                                                      |                                                            |
| <b>Responsibility:</b> | Owner provided, Contractor installed                                                 |                                                            |
| <b>Image:</b>          |  |                                                            |

Missouri State Highway Patrol  
Dormitory Renovation

|                        |                                                                                                  |                   |                                                            |
|------------------------|--------------------------------------------------------------------------------------------------|-------------------|------------------------------------------------------------|
| <b>Tag:</b>            | <b>DSK-1</b>                                                                                     |                   |                                                            |
| <b>Product:</b>        | <b>Work Table with Pencil Drawer</b>                                                             | <b>Qty:</b>       | <b>124</b>                                                 |
| <b>Manufacturer:</b>   | <b>MVE (Basis-of-Design)</b>                                                                     | <b>Lead Time:</b> | Weeks                                                      |
|                        |                                                                                                  | <b>Warranty:</b>  | Years                                                      |
|                        |                                                                                                  | <b>Location:</b>  | <b>Rooms:</b><br>Refer to Furniture Plans<br>for Locations |
| <b>Description:</b>    | Study desk with pencil drawer, oak construction, laminate top<br>Dimensions: 36"W x 24"D x 30" H |                   |                                                            |
| <b>Finish/Color:</b>   | Wood: Oak; Stain: Dark Oak                                                                       |                   |                                                            |
| <b>Options:</b>        |                                                                                                  |                   |                                                            |
| <b>Responsibility:</b> | Owner provided, Contractor installed                                                             |                   |                                                            |
| <b>Image:</b>          |              |                   |                                                            |

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|---------------|-----------------------|------------|-----------------------------------------------------|--|
| Tag:          | DSK-2                 |            |                                                     |  |
| Product:      | Desk Carrell          | Qty:       | 124                                                 |  |
| Manufacturer: | MVE (Basis-of-Design) | Lead Time: | Weeks                                               |  |
|               |                       | Warranty:  | Years                                               |  |
|               |                       | Location:  | Rooms:<br>Refer to Furniture Plans<br>for Locations |  |

|                 |                                                                                      |
|-----------------|--------------------------------------------------------------------------------------|
| Description:    | Desktop Storage unit                                                                 |
|                 | Dimensions: 36"W x 12"D x 26"H<br>One Shelf                                          |
|                 |                                                                                      |
|                 |                                                                                      |
|                 |                                                                                      |
| Finish/Color:   | Wood: Oak, Stain: Dark Oak                                                           |
| Options:        | LED light under shelf                                                                |
| Responsibility: | Owner provided, Contractor installed                                                 |
| Image:          |  |



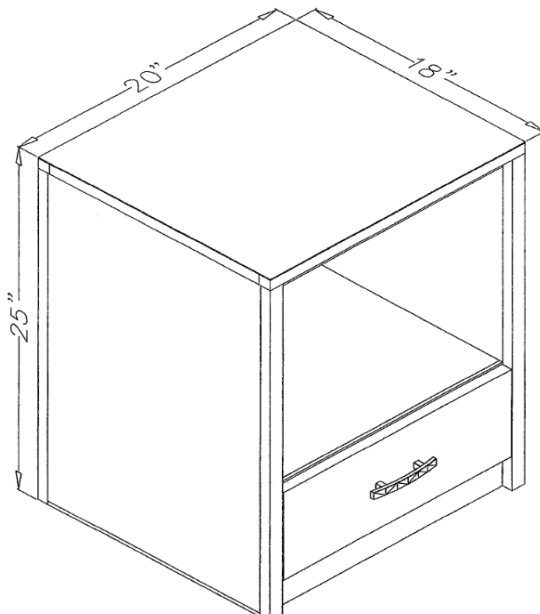
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|                        |                                                                                                                                                                                                                                                     |                   |                                                            |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------------------------------------------------------------|
| <b>Tag:</b>            | <b>DSK-3</b>                                                                                                                                                                                                                                        |                   |                                                            |
| <b>Product:</b>        | <b>Directors Collection Desk with Return</b>                                                                                                                                                                                                        | <b>Qty:</b>       | <b>13</b>                                                  |
| <b>Manufacturer:</b>   | <b>MVE (Basis-of-Design)</b>                                                                                                                                                                                                                        | <b>Lead Time:</b> | Weeks                                                      |
|                        |                                                                                                                                                                                                                                                     | <b>Warranty:</b>  | Years                                                      |
|                        |                                                                                                                                                                                                                                                     | <b>Location:</b>  | <b>Rooms:</b><br>Refer to Furniture Plans<br>for Locations |
| <b>Description:</b>    | Dimensions: 30"H x 30"W x 72"L, Return: 30"H x 24"W, x 53.25"L<br>Desk with center kneehole drawer w/ lock, 2-box drawers, file drawer w/ lockm grommets on top and center front panel. Return has keyboard pullout, grommet on top and back panel. |                   |                                                            |
| <b>Finish/Color:</b>   | Wood: Oak, Stain English Oak                                                                                                                                                                                                                        |                   |                                                            |
| <b>Options:</b>        | Left or Right return.                                                                                                                                                                                                                               |                   |                                                            |
| <b>Responsibility:</b> | Owner provided, Contractor installed                                                                                                                                                                                                                |                   |                                                            |
| <b>Image:</b>          |                                                                                                                                                                 |                   |                                                            |

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|------------------------|----------------------------------------------------------------------------------------------------------------------------------|-------------------|-------------------------------------------|
| <b>Tag:</b>            | <b>LT-1</b>                                                                                                                      |                   |                                           |
| <b>Product:</b>        | <b>Table Lamp (CT5382)</b>                                                                                                       | <b>Qty:</b>       | <b>66</b>                                 |
| <b>Manufacturer:</b>   | <b>Mario Lighting (Basis-of-Design)</b>                                                                                          | <b>Lead Time:</b> | Weeks                                     |
|                        | <b>Approved Equivalents:</b>                                                                                                     | <b>Warranty:</b>  | Years                                     |
|                        | <b>Visa Lighting - Allegro</b>                                                                                                   |                   |                                           |
|                        | <b>Remington Lighting - Style 13567.01</b>                                                                                       | <b>Location:</b>  | <b>Rooms:</b>                             |
|                        |                                                                                                                                  |                   | Refer to Furniture Plans<br>for Locations |
| <b>Description:</b>    | Table lamp with classic shade, On/Off rocker at base, USB<br>& Base switch<br>Dimensions: 13"T x 13"B x 10"H - cream Linen Shade |                   |                                           |
| <b>Finish/Color:</b>   | White                                                                                                                            |                   |                                           |
| <b>Options:</b>        | N/A                                                                                                                              |                   |                                           |
| <b>Responsibility:</b> | Owner provided, Contractor installed                                                                                             |                   |                                           |
| <b>Image:</b>          |                                               |                   |                                           |

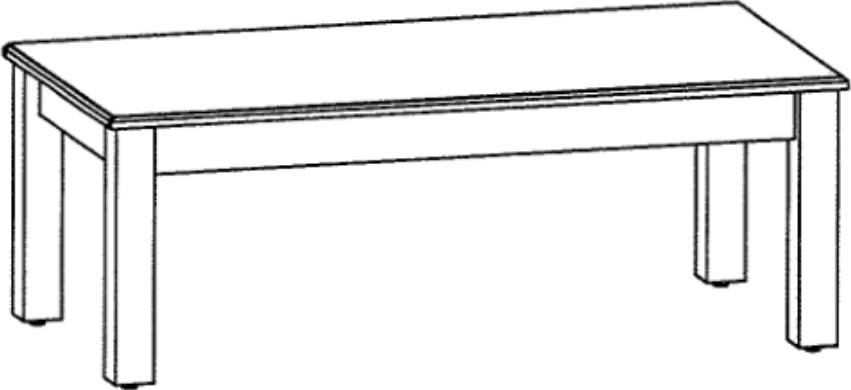
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|                 |                                                                                         |                                                     |
|-----------------|-----------------------------------------------------------------------------------------|-----------------------------------------------------|
| Tag:            | NS-1                                                                                    |                                                     |
| Product:        | Night Stand                                                                             | Qty: 66                                             |
| Manufacturer:   | MVE (Basis-of-Design)                                                                   | Lead Time: Weeks<br>Warranty: Years                 |
|                 | Location:                                                                               | Rooms:<br>Refer to Furniture Plans<br>for Locations |
| Description:    | Nightstand with top drawer and open compartment below<br>Dimensions: 20"W x 18"D x 25"H |                                                     |
| Finish/Color:   | Wood: Oak, Stain: Dark Oak                                                              |                                                     |
| Options:        | N/A                                                                                     |                                                     |
| Responsibility: | Owner provided, Contractor installed                                                    |                                                     |
| Image:          |     |                                                     |

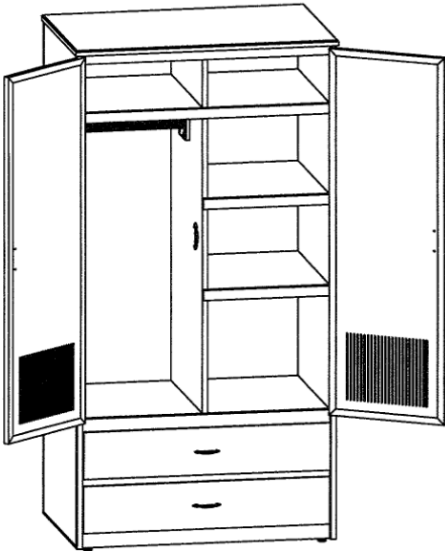
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|------------------------|-------------------------------------------------------------------------------------------------|------------------------------------------------------------|
| <b>Tag:</b>            | <b>SOF-1</b>                                                                                    |                                                            |
| <b>Product:</b>        | Suave Sofa                                                                                      | <b>Qty:</b> 2                                              |
| <b>Manufacturer:</b>   | MVE (Basis-of-Design)                                                                           | <b>Lead Time:</b> Weeks                                    |
|                        |                                                                                                 | <b>Warranty:</b> Years                                     |
|                        | <b>Location:</b>                                                                                | <b>Rooms:</b><br>Refer to Furniture Plans<br>for Locations |
| <b>Description:</b>    | Fully upholstered sofa<br><br>Dimensions: 78"L x 33.5"W x 28.25"H<br>Attached cushions standard |                                                            |
| <b>Finish/Color:</b>   | Duraweave 10, Indigo                                                                            |                                                            |
| <b>Options:</b>        | Silver post legs or wooden legs                                                                 |                                                            |
| <b>Responsibility:</b> | Owner provided, Contractor installed                                                            |                                                            |
| <b>Image:</b>          |             |                                                            |

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|------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------|
| <b>Tag:</b>            | <b>T-1</b>                                                                           |                                                            |
| <b>Product:</b>        | Coffee Table                                                                         | <b>Qty:</b> 2                                              |
| <b>Manufacturer:</b>   | MVE (Basis-of-Design)                                                                | <b>Lead Time:</b> Weeks<br><b>Warranty:</b> Years          |
|                        | <b>Location:</b>                                                                     | <b>Rooms:</b><br>Refer to Furniture Plans<br>for Locations |
| <b>Description:</b>    | Coffee Table with Laminate top<br><br>Dimensions: 48"W x 24"D x 18"H                 |                                                            |
| <b>Finish/Color:</b>   | Wood: Oak, Stain: Dark Oak, Laminate: English Oak                                    |                                                            |
| <b>Options:</b>        |                                                                                      |                                                            |
| <b>Responsibility:</b> | Owner provided, Contractor installed                                                 |                                                            |
| <b>Image:</b>          |  |                                                            |

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|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|
| <b>Tag:</b>            | <b>WRD-1</b>                                                                                                                              |                                                            |
| <b>Product:</b>        | <b>Double Wardrobe</b>                                                                                                                    | <b>Qty:</b> <b>122</b>                                     |
| <b>Manufacturer:</b>   | <b>MVE (Basis-of-Design)</b>                                                                                                              | <b>Lead Time:</b> Weeks<br><b>Warranty:</b> Years          |
|                        | <b>Location:</b>                                                                                                                          | <b>Rooms:</b><br>Refer to Furniture Plans<br>for Locations |
| <b>Description:</b>    | Deluxe double door wardrobe with flat panel doors,<br>interior shelves, two (2) drawers and clothes rod<br>Dimensions: 36"W x 24"D x 74"H |                                                            |
| <b>Finish/Color:</b>   | Wood: Oak, Stain: Dark Oak, Laminate: English Oak                                                                                         |                                                            |
| <b>Options:</b>        | Add a lock and louvers                                                                                                                    |                                                            |
| <b>Responsibility:</b> | Owner provided, Contractor installed                                                                                                      |                                                            |
| <b>Image:</b>          |                                                       |                                                            |