

**PART 5 - HEATING, VENTILATING, AIR CONDITIONING & REFRIGERATION WORK**

## **SECTION 23 05 00 BASIC MECHANICAL MATERIALS AND METHODS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract.

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Piping materials and installation instructions common to most piping systems.
  - 2. Transition fittings.
  - 3. Dielectric fittings.
  - 4. Mechanical sleeve seals.
  - 5. Sleeves.
  - 6. Escutcheons.
  - 7. Grout.
  - 8. Mechanical demolition.
  - 9. Equipment installation requirements common to equipment sections.
  - 10. Painting and finishing.
  - 11. Concrete bases.
  - 12. Supports and anchorages.

#### **1.3 DEFINITIONS**

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. CPVC: Chlorinated polyvinyl chloride plastic.
3. PE: Polyethylene plastic.
4. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

#### **1.4 SUBMITTALS**

A. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

B. Welding certificates.

#### **1.5 QUALITY ASSURANCE**

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

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

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

## **1.7 COORDINATION**

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

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
  - 2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

### **2.2 PIPE, TUBE, AND FITTINGS**

- A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

### **2.3 JOINING MATERIALS**

- A. Refer to individual Division 23 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
    - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
    - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
  2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
- F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

#### **2.4 DIELECTRIC FITTINGS**

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
1. Manufacturers:
    - a. Capitol Manufacturing Co.
    - b. Central Plastics Company.
    - c. Eclipse, Inc.
    - d. Epco Sales, Inc.
    - e. Hart Industries, International, Inc.
    - f. Watts Industries, Inc.; Water Products Div.
    - g. Zurn Industries, Inc.; Wilkins Div.
- D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
1. Manufacturers:
    - a. Capitol Manufacturing Co.

- b. Central Plastics Company.
  - c. Epco Sales, Inc.
  - d. Watts Industries, Inc.; Water Products Div.
- E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
  - 1. Manufacturers:
    - a. Advance Products & Systems, Inc.
    - b. Calpico, Inc.
    - c. Central Plastics Company.
    - d. Pipeline Seal and Insulator, Inc.
  - 2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.
- F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
  - 1. Manufacturers:
    - a. Calpico, Inc.
    - b. Lochinvar Corp.
- G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.
  - 1. Manufacturers:
    - a. Perfection Corp.
    - b. Precision Plumbing Products, Inc.
    - c. Sioux Chief Manufacturing Co., Inc.
    - d. Victaulic Co. of America.

## **2.5 MECHANICAL SLEEVE SEALS**

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
  - 1. Manufacturers:
    - a. Advance Products & Systems, Inc.
    - b. Calpico, Inc.
    - c. Metraflex Co.
    - d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Stainless steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

## **2.6 SLEEVES**

- A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
- C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
  1. Underdeck Clamp: Clamping ring with set screws.
- E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
- F. PVC Pipe: ASTM D 1785, Schedule 40.
- G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

## **2.7 ESCUTCHEONS**

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

- F. Split-Plate, Stamped-Steel Type: With exposed-rivet hinge, set screw or spring clips, and chrome-plated finish.
- G. One-Piece, Floor-Plate Type: Cast-iron floor plate.
- H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

## **2.8 GROUT**

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
  - 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
  - 2. Design Mix: 5000-psi, 28-day compressive strength.
  - 3. Packaging: Premixed and factory packaged.

## **PART 3 - EXECUTION**

### **3.1 PIPING SYSTEMS - COMMON REQUIREMENTS**

- A. Install piping according to the following requirements and Division 15 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.



- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
  - 1. New Piping:
    - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
    - b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
    - c. Insulated Piping: One-piece, stamped-steel type with spring clips.
    - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
    - e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
    - f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
    - g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.
    - h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
    - i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed or exposed-rivet hinge and set screw or spring clips.
    - j. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
    - k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
    - l. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
  - 2. Existing Piping: Use the following:
    - a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
    - b. Insulated Piping: Split-plate, stamped-steel type with concealed or exposed-rivet hinge and spring clips.
    - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
    - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
    - e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
    - f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
    - g. Bare Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated finish.
    - h. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed or exposed-rivet hinge and set screw or spring clips.
    - i. Bare Piping in Equipment Rooms: Split-casting, cast-brass type.

- j. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
  - k. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
- M. Sleeves are not required for core-drilled holes.
- N. Permanent sleeves are not required for holes formed by removable PE sleeves.
- O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
- P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
  - 1. Cut sleeves to length for mounting flush with both surfaces.
    - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
  - 2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
  - 3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
    - a. PVC Steel Pipe Sleeves: For pipes smaller than NPS 6.
    - b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
    - c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 7 Section "Sheet Metal Flashing and Trim" for flashing.
      - 1) Seal space outside of sleeve fittings with grout.
  - 4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 7 Section "Joint Sealants" for materials and installation.
- Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
  - 1. Install steel pipe for sleeves smaller than 6 inches in diameter.
  - 2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
  - 3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten

bolts against pressure plates that cause sealing elements to expand and make watertight seal.

- R. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
  - 1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 7 Section "Through-Penetration Firestop Systems" for materials.
- T. Verify final equipment locations for roughing-in.
- U. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

### **3.2 PIPING JOINT CONSTRUCTION**

- A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
  - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
  - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

### **3.3 PIPING CONNECTIONS**

- A. Make connections according to the following, unless otherwise indicated:
  - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
  - 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
  - 3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
  - 4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

### **3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS**

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.

### **3.5 PAINTING**

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

### **3.6 CONCRETE BASES**

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
  - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported 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. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 3 Section " Cast-in-Place Concrete (Limited Applications)."

### **3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES**

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

### **3.8 GROUTING**

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

**END OF SECTION**

## **SECTION 230513 COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract.

#### **1.2 SUMMARY**

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

#### **1.3 COORDINATION**

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

### **PART 2 - PRODUCTS**

#### **2.1 GENERAL MOTOR REQUIREMENTS**

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.

#### **2.2 MOTOR CHARACTERISTICS**

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

## **2.3 POLYPHASE MOTORS**

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
  - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
  - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F-
- J. Code Letter Designation:
  - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
  - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T

## **2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS**

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
  - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
  - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
  - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
  - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

## **2.5 SINGLE-PHASE MOTORS**

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
  - 1. Permanent-split capacitor.
  - 2. Split phase.
  - 3. Capacitor start, inductor run.
  - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

### **PART 3 - EXECUTION (Not Applicable)**

**END OF SECTION 230513**



## **SECTION 230523.12 BALL VALVES FOR HVAC PIPING**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Bronze ball valves.
  - 2. Steel ball valves.

#### **1.3 DEFINITIONS**

- A. CWP: Cold working pressure.
- B. SWP: Steam working pressure.

#### **1.4 ACTION SUBMITTALS**

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

#### **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 weld ends.
  - 3. Set ball valves open to minimize exposure of functional surfaces.
- B. Use the following precautions during storage:
  - 1. Maintain valve end protection.
  - 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL REQUIREMENTS FOR VALVES**

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
  - 1. ASME B1.20.1 for threads for threaded-end valves.
  - 2. ASME B16.1 for flanges on iron valves.
  - 3. ASME B16.5 for flanges on steel valves.
  - 4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
  - 5. ASME B16.18 for solder-joint connections.
  - 6. ASME B31.1 for power piping valves.
  - 7. ASME B31.9 for building services piping valves.
- C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- D. Refer to HVAC valve schedule articles for applications of valves.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Actuator Types:
  - 1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
  - 2. Handlever: For quarter-turn valves smaller than NPS 4.
- H. Valves in Insulated Piping:
  - 1. Include 2-inch stem extensions.
  - 2. Extended operating handle of nonthermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
  - 3. Memory stops that are fully adjustable after insulation is applied.
- I. Valve Bypass and Drain Connections: MSS SP-45.

### **2.2 BRONZE BALL VALVES**

- A. Two-Piece Bronze Ball Valves with Full Port and Stainless-Steel Trim:
  - 1. Manufacturers
    - a. Crane; Crane Energy Flow Solutions
    - b. Milwaukee Valves

- c. NIBCO, Inc.
- d. Watts

2. Description:

- a. Standard: MSS SP-110.
- b. SWP Rating: 150 psig.
- c. CWP Rating: 600 psig.
- d. Body Design: Two piece.
- e. Body Material: Bronze.
- f. Ends: Threaded.
- g. Seats: PTFE.
- h. Stem: Stainless steel.
- i. Ball: Stainless steel, vented.
- j. Port: Full.

### 2.3 STEEL BALL VALVES

A. Class 150 Steel Ball Valves with Full Port and Stainless-Steel Trim:

1. Manufacturers

- a. Conbraco
- b. Jamesbry; Metso
- c. NIBCO, Inc.

2. Description:

- a. Standard: MSS SP-72.
- b. CWP Rating: 285 psig.
- c. Body Design: Split body.
- d. Body Material: Carbon steel, ASTM A 216, Type WCB.
- e. Ends: Flanged.
- f. Seats: PTFE.
- g. Stem: Stainless steel.
- h. Ball: Stainless steel, vented.

### 2.4 IRON BALL VALVES

A. Class 125 Iron Ball Valves:

1. Manufacturers

- a. American Valve, Inc
- b. Conbraco
- c. Milwaukee Valves
- d. Watts

2. Description:

- a. Standard: MSS SP-72.
- b. CWP Rating: 200 psig.
- c. Body Design: Split body.
- d. Body Material: ASTM A 126, gray iron.
- e. Ends: Flanged.
- f. Seats: PTFE.
- g. Stem: Stainless steel.
- h. Ball: Stainless steel.
- i. Port: Full.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

#### **3.2 VALVE INSTALLATION**

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install valve tags. Comply with requirements of Owner for valve tags and schedules.

#### **3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS**

- A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

- B. Select valves with the following end connections:
1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
  2. For Steel Piping, NPS 2 and Smaller: Threaded ends.
  3. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
  4. For Steel Piping, NPS 5 and Larger: Flanged ends.

**3.4 CHILLED-WATER VALVE SCHEDULE**

- A. Refer to Contract Drawings

**3.5 CONDENSER-WATER VALVE SCHEDULE**

- A. Refer to Contract Drawings

**3.6 HEATING-WATER VALVE SCHEDULE**

- A. Refer to Contract Drawings

**3.7 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG OR LESS)**

- A. Refer to Contract Drawings

**3.8 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG)**

- A. Refer to Contract Drawings

**3.9 STEAM-CONDENSATE VALVE SCHEDULE**

- A. Refer to Contract Drawings

END OF SECTION 230523.12

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

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Metal pipe hangers and supports.
  - 2. Trapeze pipe hangers.
  - 3. Fastener systems.
  - 4. Pipe stands.
  - 5. Equipment supports.
- B. Related Sections:
  - 1. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
  - 2. Section 233113 "Metal Ducts" for duct hangers and supports.

#### **1.3 DEFINITIONS**

- A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

#### **1.4 PERFORMANCE REQUIREMENTS**

- A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
  - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
  - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

## **1.5 ACTION SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
  - 1. Trapeze pipe hangers.
  - 2. Pipe stands.
  - 3. Equipment supports.
- C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - 1. Detail fabrication and assembly of trapeze hangers.
  - 2. Design Calculations: Calculate requirements for designing trapeze hangers.

## **1.6 INFORMATIONAL SUBMITTALS**

- A. Welding certificates.

## **1.7 QUALITY ASSURANCE**

- A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

## **PART 2 - PRODUCTS**

### **2.1 METAL PIPE HANGERS AND SUPPORTS**

- A. Carbon-Steel Pipe Hangers and Supports:
  - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
  - 2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
  - 3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
  - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
  - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

## **2.2 TRAPEZE PIPE HANGERS**

- A. Description: MSS SP-69, 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.

## **2.3 FASTENER SYSTEMS**

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

## **2.4 PIPE STANDS**

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand:
  1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
  2. Base: Stainless steel.
  3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
  4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- E. High-Type, Multiple-Pipe Stand:
  1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
  2. Bases: One or more; plastic.



3. Vertical Members: Two or more protective-coated-steel channels.
  4. Horizontal Member: Protective-coated-steel channel.
  5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
- F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

## **2.5 EQUIPMENT SUPPORTS**

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

## **2.6 MISCELLANEOUS MATERIALS**

- A. Structural Steel: ASTM A 36/A 36M, carbon-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 INSTALLATION**

- A. Metal 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 the building structure.
- B. Metal 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 for individual pipe hangers.
  2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Fastener System Installation:
1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use

- operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- D. 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.
- E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- G. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- H. Install lateral bracing with pipe hangers and supports to prevent swaying.
- I. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- K. 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.
- L. Insulated Piping:
1. Attach clamps and spacers to piping.
    - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
  2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

- a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
- 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
  - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
- 4. Shield Dimensions for Pipe: Not less than the following:
  - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
  - b. NPS 4: 12 inches long and 0.06 inch thick.
  - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
  - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
  - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
- 5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
- 6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

### **3.2 EQUIPMENT SUPPORTS**

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

### **3.3 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 because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
  - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  - 2. Obtain fusion without undercut or overlap.
  - 3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

### **3.4 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: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

### **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-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 carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.
- H. Use thermal-hanger shield inserts for insulated piping and tubing.
- I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

- J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
  2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
- K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
  2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
  3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
  4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
  5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
  2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
  3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
  4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
  5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
  6. C-Clamps (MSS Type 23): For structural shapes.
  7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
  8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
  9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
  10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
  11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
  12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    - a. Light (MSS Type 31): 750 lb.
    - b. Medium (MSS Type 32): 1500 lb.
    - c. Heavy (MSS Type 33): 3000 lb.
  13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
  14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
  2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
  3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
  2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
  3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
  4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
  5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
  6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
  7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
  8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
    - a. Horizontal (MSS Type 54): Mounted horizontally.
    - b. Vertical (MSS Type 55): Mounted vertically.
    - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

**END OF SECTION 230529**



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

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Balancing Air Systems:
    - a. Constant-volume air systems.
    - b. Variable-air-volume systems.
    - c. Induction-unit systems.
  - 2. Balancing Hydronic Piping Systems:
    - a. Constant-flow hydronic systems.
    - b. Variable-flow hydronic systems.
    - c. Primary-secondary hydronic systems.
  - 3. Balancing steam systems.
  - 4. Testing, Adjusting, and Balancing Equipment:
    - a. Heat exchangers.
    - b. Motors.
    - c. Chillers.
    - d. Cooling towers.
    - e. Condensing units.
    - f. Boilers.
    - g. Heat-transfer coils.
  - 5. Testing, adjusting, and balancing existing systems and equipment.
  - 6. Sound tests.
  - 7. Vibration tests.
  - 8. Duct leakage tests.
  - 9. Control system verification.

#### **1.3 DEFINITIONS**

- A. AABC: Associated Air Balance Council.

- B. BAS: Building automation systems.
- C. NEBB: National Environmental Balancing Bureau.
- D. TAB: Testing, adjusting, and balancing.
- E. TABB: Testing, Adjusting, and Balancing Bureau.
- F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- G. TDH: Total dynamic head.

#### **1.4 PREINSTALLATION MEETINGS**

- A. TAB Conference: If requested by the Owner, 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 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. Contract Documents Examination Report: Within 60 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- C. 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.
- D. System Readiness Checklists: Within 60 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 NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by AABC NEBB or TABB as a TAB technician.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

## **1.7 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.

## **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:

1. BD Abel
2. Baltonix
3. Fisher Balancing

#### 4. Independent Balancing

### 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, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.
  - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
  - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

- L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.
- P. 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 HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
  - 1. Airside:
    - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
    - b. Duct systems are complete with terminals installed.
    - c. Volume, smoke, and fire dampers are open and functional.
    - d. Clean filters are installed.
    - e. Fans are operating, free of vibration, and rotating in correct direction.
    - f. Variable-frequency controllers' startup is complete and safeties are verified.
    - g. Automatic temperature-control systems are operational.
    - h. Ceilings are installed.
    - i. Windows and doors are installed.
    - j. Suitable access to balancing devices and equipment is provided.
  - 2. Hydronics:
    - a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
    - b. Piping is complete with terminals installed.
    - c. Water treatment is complete.
    - d. Systems are flushed, filled, and air purged.
    - e. Strainers are pulled and cleaned.
    - f. Control valves are functioning per the sequence of operation.

- g. Shutoff and balance valves have been verified to be 100 percent open.
- h. Pumps are started and proper rotation is verified.
- i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
- j. Variable-frequency controllers' startup is complete and safeties are verified.
- k. Suitable access to balancing devices and equipment is provided.

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

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" **or** NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
  - 1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
  - 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

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

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.

- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

### **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 Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
  - 2. Measure fan static pressures as follows:
    - a. Measure static pressure directly at the fan outlet or through the flexible connection.
    - b. Measure static pressure directly at the fan inlet or through the flexible connection.
    - c. Measure static pressure across each component that makes up the air-handling system.
    - d. Report artificial loading of filters at the time static pressures are measured.
  - 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
  - 4. Obtain approval from Owner **or** Construction Manager for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
  - 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
  - 1. Measure airflow of submain and branch ducts.
  - 2. Adjust submain and branch duct volume dampers for specified airflow.
  - 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
  - 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
  - 2. Measure inlets and outlets airflow.
  - 3. Adjust each inlet and outlet for specified airflow.
  - 4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.
  - 1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
  - 2. Re-measure and confirm that total airflow is within design.
  - 3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
  - 4. Mark all final settings.
  - 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
  - 6. Measure and record all operating data.
  - 7. Record final fan-performance data.

### **3.7 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. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
  - g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
- a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
  - b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
  - c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
  - d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
  - e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
6. Measure fan static pressures as follows:
- a. Measure static pressure directly at the fan outlet or through the flexible connection.
  - b. Measure static pressure directly at the fan inlet or through the flexible connection.
  - c. Measure static pressure across each component that makes up the air-handling system.
  - d. Report any artificial loading of filters at the time static pressures are measured.
7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
- a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
  - 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, rpms, 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 PROCEDURES FOR INDUCTION-UNIT SYSTEMS**

- A. Balance primary-air risers by measuring static pressure at the nozzles of the top and bottom units of each riser to determine which risers must be throttled. Adjust risers to indicated airflow within specified tolerances.
- B. Adjust each induction unit.
- C. 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 Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
  - 2. Measure fan static pressures as follows:
    - a. Measure static pressure directly at the fan outlet or through the flexible connection.
    - b. Measure static pressure directly at the fan inlet or through the flexible connection.
    - c. Measure static pressure across each component that makes up the air-handling system.
    - d. Report artificial loading of filters at the time static pressures are measured.
  - 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
  - 4. Obtain approval from Owner or Construction Manager for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.

5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- D. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
1. Measure airflow of submain and branch ducts.
  2. Adjust submain and branch duct volume dampers for specified airflow.
  3. Re-measure each submain and branch duct after all have been adjusted.
- E. Balance airflow to each induction unit by measuring the nozzle pressure and comparing it to the manufacturer's published data for nozzle pressure versus cfm. Adjust the unit's inlet damper to achieve the required nozzle pressure for design cfm.
- F. Verify final system conditions.
1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
  2. Re-measure and confirm that total airflow is within design.
  3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
  4. Mark all final settings.
  5. Test system in economizer mode. Verify proper operation and adjust if necessary.
  6. Measure and record all operating data.
  7. Record final fan-performance data.

### **3.9 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS**

- A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
1. Check liquid level in expansion tank.
  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 starters.
  5. Verify that motor starters are equipped with properly sized thermal protection.
  6. Check that air has been purged from the system.

### 3.10 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

- A. Adjust pumps to deliver total design gpm.
  - 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 exchanger 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 gage heights.
    - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
    - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
  - 3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
- B. 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.
- C. 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.
- D. For systems with pressure-independent valves at terminals:
  - 1. Measure differential pressure and verify that it is within manufacturer's specified range.
  - 2. Perform temperature tests after flows have been verified.
- E. 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.
- F. 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, and static profile.
  3. Mark final settings.
- G. Verify that memory stops have been set.

### **3.11 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 differential-pressure sensor is located as indicated.
  2. Determine whether there is diversity in the system.
- C. For systems with no diversity:
1. Adjust pumps to deliver total design gpm.
    - 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 exchanger 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 gage 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.
      - 5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

- c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
  2. 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.
  3. 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.
  4. 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.
  5. 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.
  6. Prior to verifying final system conditions, determine the system differential-pressure set point.
  7. 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.
  8. Mark final settings and verify that all memory stops have been set.
  9. 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, and static profile.
    - c. Mark final settings.
  10. Verify that memory stops have been set.
- D. For systems with diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
3. Adjust pumps to deliver total design gpm.
  - 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 exchanger 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 gage 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.
    - 5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
  - c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
4. 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.
5. 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.
6. 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.

7. 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.
8. 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.
9. Prior to verifying final system conditions, determine system differential-pressure set point.
10. 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.
11. Mark final settings and verify that memory stops have been set.
12. 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, and static profile.
  - c. Mark final settings.
13. Verify that memory stops have been set.

### **3.12 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 gpm.
  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 exchanger 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 gage heights.



- d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
    - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
  3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
- D. Adjust flow-measuring devices installed in mains and branches to design water flows.
  1. Measure flow in main and branch pipes.
  2. Adjust main and branch balance valves for design flow.
  3. Re-measure each main and branch after all have been adjusted.
- E. Adjust flow-measuring devices installed at terminals for each space to design water flows.
  1. Measure flow at terminals.
  2. Adjust each terminal to design flow.
  3. Re-measure each terminal after it is adjusted.
  4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
  5. Perform temperature tests after flows have been balanced.
- F. For systems with pressure-independent valves at terminals:
  1. Measure differential pressure and verify that it is within manufacturer's specified range.
  2. Perform temperature tests after flows have been verified.
- G. For systems without pressure-independent valves or flow-measuring devices at terminals:
  1. Measure and balance coils by either coil pressure drop or temperature method.
  2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- H. Verify final system conditions as follows:
  1. Re-measure and confirm that total water flow is within design.
  2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
  3. Mark final settings.
- I. Verify that memory stops have been set.

### **3.13 PROCEDURES FOR STEAM SYSTEMS**

- A. Measure and record upstream and downstream pressure of each piece of equipment.
- B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.

- C. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
- D. Check settings and operation of each safety valve. Record settings.
- E. Verify the operation of each steam trap.

#### 3.14 PROCEDURES FOR HEAT EXCHANGERS

- A. Adjust water flow to within specified tolerances.
- B. Measure inlet and outlet water temperatures.
- C. Measure inlet steam pressure.
- D. Check settings and operation of safety and relief valves. Record settings.

#### 3.15 PROCEDURES FOR MOTORS

- A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:
  - 1. Manufacturer's name, model number, and serial number.
  - 2. Motor horsepower rating.
  - 3. Motor rpm.
  - 4. Phase and hertz.
  - 5. Nameplate and measured voltage, each phase.
  - 6. Nameplate and measured amperage, each phase.
  - 7. Starter size and thermal-protection-element rating.
  - 8. Service factor and frame size.
- B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

#### 3.16 PROCEDURES FOR CHILLERS

- A. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
  - 1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
  - 2. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
  - 3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
  - 4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.

5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
6. Capacity: Calculate in tons of cooling.
7. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

### **3.17 PROCEDURES FOR COOLING TOWERS**

- A. Balance total condenser-water flows to towers. Measure and record the following data:
  1. Condenser-water flow to each cell of the cooling tower.
  2. Entering- and leaving-water temperatures.
  3. Wet- and dry-bulb temperatures of entering air.
  4. Wet- and dry-bulb temperatures of leaving air.
  5. Condenser-water flow rate recirculating through the cooling tower.
  6. Cooling-tower spray pump discharge pressure.
  7. Condenser-water flow through bypass.
  8. Fan and motor operating data.

### **3.18 PROCEDURES FOR CONDENSING UNITS**

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record fan and motor operating data.

### **3.19 PROCEDURES FOR BOILERS**

- A. Hydronic Boilers:
  1. Measure and record entering- and leaving-water temperatures.
  2. Measure and record water flow.
  3. Record relief valve pressure setting.
- B. Steam Boilers:
  1. Measure and record entering-water temperature.
  2. Measure and record feed water flow.
  3. Measure and record leaving-steam pressure and temperature.
  4. Record relief valve pressure setting.

### **3.20 PROCEDURES FOR HEAT-TRANSFER COILS**

- A. Measure, adjust, and record the following data for each water coil:
  1. Entering- and leaving-water temperature.

2. Water flow rate.
  3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
  4. Dry-bulb temperature of entering and leaving air.
  5. Wet-bulb temperature of entering and leaving air for cooling coils.
  6. Airflow.
- B. Measure, adjust, and record the following data for each electric heating coil:
1. Nameplate data.
  2. Airflow.
  3. Entering- and leaving-air temperature at full load.
  4. Voltage and amperage input of each phase at full load.
  5. Calculated kilowatt at full load.
  6. Fuse or circuit-breaker rating for overload protection.
- C. Measure, adjust, and record the following data for each steam coil:
1. Dry-bulb temperature of entering and leaving air.
  2. Airflow.
  3. Inlet steam pressure.
- D. Measure, adjust, and record the following data for each refrigerant coil:
1. Dry-bulb temperature of entering and leaving air.
  2. Wet-bulb temperature of entering and leaving air.
  3. Airflow.

### **3.21 SOUND TESTS**

- A. After the systems are balanced and construction is Substantially Complete, measure and record sound levels at 10 locations as designated by the Engineer or Owner.
- B. Instrumentation:
1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
  2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels, and measuring the equivalent continuous sound pressure level (LEQ).
  3. The sound-testing meter must be capable of using 1/3 octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.
  4. The accuracy of the sound-testing meter shall be plus or minus one decibel.
- C. Test Procedures:
1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
  2. Equipment should be operating at design values.

3. Calibrate the sound-testing meter prior to taking measurements.
4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.
5. Record a set of background measurements in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC) with the equipment off.
6. Take sound readings in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC) with the equipment operating.
7. Take readings no closer than 36 inches from a wall or from the operating equipment and approximately 60 inches from the floor, with the meter held or mounted on a tripod.
8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:

1. Report shall record the following:
  - a. Location.
  - b. System tested.
  - c. dBA reading.
  - d. Sound pressure level in each octave band with equipment on and off.
2. Plot sound pressure levels on NC worksheet with equipment on and off.

### **3.22 VIBRATION TESTS**

- A. After systems are balanced and construction is Substantially Complete, measure and record vibration levels on equipment having motor horsepower equal to or greater than 15.
- B. Instrumentation:
  1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
  2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.
  3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.
  4. Verify calibration date is current for vibration meter before taking readings.
- C. Test Procedures:
  1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.
  2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial

reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.

3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.
4. Record CPM or rpm.
5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.

D. Reporting:

1. Report shall record location and the system tested.
2. Include horizontal-vertical-axial measurements for tests.
3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from the AABC National Standards. Acceptable levels of vibration are normally "smooth" to "good."
4. Include in report General Machinery Vibration Severity Chart, with conditions plotted.

### **3.23 DUCT LEAKAGE TESTS**

- A. Witness the duct pressure testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified tolerances.
- C. Report deficiencies observed.

### **3.24 CONTROLS VERIFICATION**

- A. In conjunction with system balancing, perform the following:
  1. Verify temperature control system is operating within the design limitations.
  2. Confirm that the sequences of operation are in compliance with Contract Documents.
  3. Verify that controllers are calibrated and function as intended.
  4. Verify that controller set points are as indicated.
  5. Verify the operation of lockout or interlock systems.
  6. Verify the operation of valve and damper actuators.
  7. Verify that controlled devices are properly installed and connected to correct controller.
  8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
  9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.
- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

### **3.25 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS**

- A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
  - 1. Measure and record the operating speed, airflow, and static pressure of each fan.
  - 2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
  - 3. Check the refrigerant charge.
  - 4. Check the condition of filters.
  - 5. Check the condition of coils.
  - 6. Check the operation of the drain pan and condensate-drain trap.
  - 7. Check bearings and other lubricated parts for proper lubrication.
  - 8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.
  
- B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:
  - 1. New filters are installed.
  - 2. Coils are clean and fins combed.
  - 3. Drain pans are clean.
  - 4. Fans are clean.
  - 5. Bearings and other parts are properly lubricated.
  - 6. Deficiencies noted in the preconstruction report are corrected.
  
- C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
  - 1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
  - 2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
  - 3. If calculations increase or decrease the airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
  - 4. Balance each air outlet.

### **3.26 TOLERANCES**

- A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
  - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 5 percent.
  - 2. Air Outlets and Inlets: Plus or minus 10 percent.
  - 3. Heating-Water Flow Rate: Plus or minus 5 percent.
  - 4. Cooling-Water Flow Rate: Plus or minus 5 percent.

- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

### **3.27 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 systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: Prepare biweekly 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.

### **3.28 FINAL REPORT**

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
  - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
  - 2. Include a list of instruments used for procedures, along with proof of calibration.
  - 3. Certify validity and accuracy of field data.
- B. Final Report Contents: In addition to certified field-report data, include the following:
  - 1. Pump curves.
  - 2. Fan curves.
  - 3. Manufacturers' test data.
  - 4. Field test reports prepared by system and equipment installers.
  - 5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.
- C. General Report Data: In addition to form titles and entries, include the following data:
  - 1. Title page.
  - 2. Name and address of the TAB specialist.
  - 3. Project name.
  - 4. Project location.
  - 5. Architect's name and address.
  - 6. Engineer's name and address.
  - 7. Contractor's name and address.
  - 8. Report date.
  - 9. Signature of TAB supervisor who certifies the report.



10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
  11. Summary of contents including the following:
    - a. Indicated versus final performance.
    - b. Notable characteristics of systems.
    - c. Description of system operation sequence if it varies from the Contract Documents.
  12. Nomenclature sheets for each item of equipment.
  13. Data for terminal units, including manufacturer's name, type, size, and fittings.
  14. Notes to explain why certain final data in the body of reports vary from indicated values.
  15. Test conditions for fans and pump 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. Face and bypass damper settings at coils.
    - e. Fan drive settings including settings and percentage of maximum pitch diameter.
    - f. Inlet vane settings for variable-air-volume systems.
    - g. Settings for supply-air, static-pressure controller.
    - h. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
  2. Water and steam flow rates.
  3. Duct, outlet, and inlet sizes.
  4. Pipe and valve sizes and locations.
  5. Terminal units.
  6. Balancing stations.
  7. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units with coils, 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 rpm.
  - 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 rpm.
  - d. Discharge static pressure in inches wg.
  - e. 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. Outdoor airflow in cfm.
  - j. Return airflow in cfm.
  - k. Outdoor-air damper position.
  - l. Return-air damper position.
  - m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:
  - a. System identification.
  - b. Location.
  - c. Coil type.
  - d. Number of rows.
  - e. Fin spacing in fins per inch o.c.
  - f. Make and model number.
  - g. Face area in sq. ft..
  - h. Tube size in NPS.
  - i. Tube and fin materials.
  - j. Circuiting arrangement.
  
2. Test Data (Indicated and Actual Values):
  - a. Airflow rate in cfm.
  - b. Average face velocity in fpm.
  - c. Air pressure drop in inches wg.
  - d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
  - e. Return-air, wet- and dry-bulb temperatures in deg F.
  - f. Entering-air, wet- and dry-bulb temperatures in deg F.
  - g. Leaving-air, wet- and dry-bulb temperatures in deg F.

- h. Water flow rate in gpm.
- i. Water pressure differential in feet of head or psig.
- j. Entering-water temperature in deg F.
- k. Leaving-water temperature in deg F.
- l. Refrigerant expansion valve and refrigerant types.
- m. Refrigerant suction pressure in psig.
- n. Refrigerant suction temperature in deg F.
- o. Inlet steam pressure in psig.

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

- a. System identification.
- b. Location.
- c. Make and type.
- d. Model number and unit size.
- e. Manufacturer's serial number.
- f. Fuel type in input data.
- g. Output capacity in Btu/h.
- h. Ignition type.
- i. Burner-control types.
- j. Motor horsepower and rpm.
- k. Motor volts, phase, and hertz.
- l. Motor full-load amperage and service factor.
- m. Sheave make, size in inches, and bore.
- n. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

- a. Total airflow rate in cfm.
- b. Entering-air temperature in deg F.
- c. Leaving-air temperature in deg F.
- d. Air temperature differential in deg F.
- e. Entering-air static pressure in inches wg.
- f. Leaving-air static pressure in inches wg.
- g. Air static-pressure differential in inches wg.
- h. Low-fire fuel input in Btu/h.
- i. High-fire fuel input in Btu/h.
- j. Manifold pressure in psig.
- k. High-temperature-limit setting in deg F.
- l. Operating set point in Btu/h.
- m. Motor voltage at each connection.
- n. Motor amperage for each phase.
- o. Heating value of fuel in Btu/h.

H. 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 rpm.
  - 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 rpm.
  - d. Discharge static pressure in inches wg.
  - e. Suction static pressure in inches wg.
  
- I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
  1. Report Data:
    - a. System and air-handling-unit number.
    - b. Location and zone.
    - c. Traverse air temperature in deg F.
    - 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.
  
- J. 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.
- K. 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.
- L. 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 rpm.
- 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.

M. Instrument Calibration Reports:

1. Report Data:

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

**3.29 VERIFICATION OF TAB REPORT**

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Owner **or** Construction Manager.
- B. Owner **or** Construction Manager shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
- 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 testing and balancing shall be considered incomplete and shall be rejected.
- E. If TAB work fails, 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.
  - 2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
  - 3. If the second verification also fails, Owner may contact AABC Headquarters regarding the AABC National Performance Guaranty.
- F. Prepare test and inspection reports.

### **3.30 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.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

**END OF SECTION 230593**

## **SECTION 230719 HVAC PIPING INSULATION**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract.

#### **1.2 SUMMARY**

- A. Section includes insulating the following HVAC piping systems:
  - 1. Heating hot-water piping, indoors.
  - 2. Chilled water piping indoors.
  - 3. Low pressure steam and condensate piping, indoors.
  - 4. High pressure steam and condensate piping, indoors.
- B. Related Sections:
  - 1. Section 230713 "Duct Insulation."
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
  - 2. Detail insulation application at pipe expansion joints for each type of insulation.
  - 3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
  - 4. Detail removable insulation at piping specialties.

#### **1.3 INFORMATIONAL SUBMITTALS**

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.



#### **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. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
  - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
  - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

#### **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 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.
- B. Coordinate installation and testing of heat tracing.

#### **1.7 SCHEDULING**

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

### **PART 2 - PRODUCTS**

#### **2.1 INSULATION MATERIALS**

- A. Comply with requirements on Contract Drawings.

- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Calcium Silicate:
  - 1. Manufacturers:
    - a. Industrial Insulation Group
  - 2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
  - 3. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
  - 4. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
- F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
  - 1. Manufacturers:
    - a. Pittsburgh Corning Corporation
  - 2. Block Insulation: ASTM C 552, Type I.
  - 3. Special-Shaped Insulation: ASTM C 552, Type III.
  - 4. Board Insulation: ASTM C 552, Type IV.
  - 5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
  - 6. Preformed Pipe Insulation with Factory-Applied **ASJ**: Comply with ASTM C 552, Type II, Class 2.
  - 7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
- G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
  - 1. Manufacturers:
    - a. Aeroflex USA, Inc.
    - b. Armacell, LLC
    - c. K-Flex USA

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

1. Manufacturers:
  - a. CertainTeed Corporation
  - b. Johns Manville.
  - c. Knauf Insulation
  - d. Manson Insulation Inc.
  - e. Owens Corning

I. Mineral-Fiber, Preformed Pipe Insulation:

1. Manufacturers:
  - a. CertainTeed Corporation
  - b. Johns Manville.
  - c. Knauf Insulation
  - d. Manson Insulation Inc.
  - e. Owens Corning
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-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

## **2.2 INSULATING CEMENTS**

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

1. Manufacturers:
  - a. Ramco Insulation, Inc.; Super-Stik.

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

1. Manufacturers:
  - a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

## **2.3 ADHESIVES**

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

1. Manufacturers:
  - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.

- b. Eagle Bridges - Marathon Industries; 225.
    - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
    - d. Mon-Eco Industries, Inc.; 22-25.
  - 2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
  - 1. Manufacturers:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
    - b. Eagle Bridges - Marathon Industries; 225.
    - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
    - d. Mon-Eco Industries, Inc.; 22-25.
  - 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

#### **2.4 FACTORY-APPLIED JACKETS**

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

#### **2.5 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. Manufacturers:
    - a. Johns Manville; Zeston.
    - b. P.I.C. Plastics, Inc.; FG Series.
    - c. Proto Corporation; LoSmoke.
    - d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
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.

## **2.6 TAPES**

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
  1. Manufacturers:
    - a. ABI, Ideal Tape Division; 428 AWF ASJ.
    - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
    - c. Compac Corporation; 104 and 105.
    - 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.

## **2.7 SECUREMENTS**

- A. Bands:
  1. Manufacturers:
    - a. ITW Insulation Systems; Gerrard Strapping and Seals.
    - b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
  2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.
- C. Wire: 0.080-inch nickel-copper alloy 0.062-inch soft-annealed, stainless steel 0.062-inch soft-annealed, galvanized steel.
  1. Manufacturers:
    - a. C & F Wire.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
  - 1. Verify that systems to be insulated have been tested and are free of defects.
  - 2. Verify that surfaces to be insulated are clean and dry.
  - 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. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
  - 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
  - 2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

### **3.3 GENERAL INSTALLATION REQUIREMENTS**

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
  - 1. Install insulation continuously through hangers and around anchor attachments.
  - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
  - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
  - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
  - 1. Draw jacket tight and smooth.
  - 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
  - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
    - a. For below-ambient services, apply vapor-barrier mastic over staples.
  - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
  - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
  - 1. Vibration-control devices.
  - 2. Testing agency labels and stamps.
  - 3. Nameplates and data plates.
  - 4. Manholes.
  - 5. Handholes.
  - 6. Cleanouts.

### **3.4 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.
- 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 Section 078413 "Penetration 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. 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 INSTALLATION OF MINERAL-FIBER INSULATION**

#### **A. Insulation Installation on Straight Pipes and Tubes:**

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

#### **B. Insulation Installation on Pipe Flanges:**

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

#### **C. Insulation Installation on Pipe Fittings and Elbows:**

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

#### **D. Insulation Installation on Valves and Pipe Specialties:**

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

### **3.7 FIELD-APPLIED JACKET INSTALLATION**

- A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. 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.

### **3.8 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 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, two locations of threaded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service.
- D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

### **3.9 PIPING INSULATION SCHEDULE, GENERAL**

- A. Refer to Contract Drawings

### **3.10 INDOOR PIPING INSULATION SCHEDULE:**

- A. Refer to Contract Drawings

**END OF SECTION 230719**

## **SECTION 232113 - HYDRONIC PIPING**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract.

#### **1.2 SUMMARY**

- A. Section includes pipe and fitting materials and joining methods for the following:
  - 1. Hot-water heating piping.
  - 2. Chilled-water piping.
  - 3. Condenser-water piping.
  - 4. Makeup-water piping.
  - 5. Condensate-drain piping.
  - 6. Blowdown-drain piping.
  - 7. Air-vent piping.
  - 8. Safety-valve-inlet and -outlet piping.

#### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of the following:
  - 1. Plastic pipe and fittings with solvent cement.
  - 2. RTRP and RTRF with adhesive.
  - 3. Pressure-seal fittings.
  - 4. Chemical treatment.
- B. Delegated-Design Submittal:
  - 1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
  - 2. Locations of pipe anchors and alignment guides and expansion joints and loops.
  - 3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
  - 4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 1. Suspended ceiling components.
  - 2. Other building services.
  - 3. Structural members.
- B. Qualification Data: For Installer.
- C. Welding certificates.
- D. Field quality-control reports.
- E. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

#### **1.5 QUALITY ASSURANCE**

- A. Installer Qualifications:
  - 1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
- B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
  - 1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
  - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

### **PART 2 - PRODUCTS**

#### **2.1 PERFORMANCE REQUIREMENTS**

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
  - 1. Hot-Water Heating Piping: 125 psigat 200 deg F
  - 2. Chilled-Water Piping: 125 psigat 200 deg F.
  - 3. Condenser-Water Piping: 125 psigat 150 deg F.

4. Makeup-Water Piping: 80 psig at 150 deg F
5. Condensate-Drain Piping: 150 deg F
6. Blowdown-Drain Piping: 200 deg F
7. Air-Vent Piping: 200 deg F
8. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

## **2.2 COPPER TUBE AND FITTINGS**

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L
- B. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.
  1. Manufacturerers
    - a. Viega
    - b. Victaulic
  2. Grooved-End Copper Fittings: ASTM B 75 copper tube or ASTM B 584, bronze casting.
  3. Grooved-End-Tube Couplings: Rigid pattern unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nuts.
- C. Copper or Bronze Pressure-Seal Fittings:
  1. Manufacturerers
    - a. Viega
    - b. Victaulic
  2. Housing: Copper.
  3. O-Rings and Pipe Stops: EPDM.
  4. Tools: Manufacturer's special tools.
  5. Minimum 200-psig working-pressure rating at 250 deg F. Verify that fittings in "Copper, Mechanically Formed Tee Option" Paragraph below are available for pipe sizes required for Project.
- D. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
  1. Manufacturerers
    - a. Viega
    - b. Victaulic
- E. Wrought-Copper Unions: ASME B16.22.

## **2.3 STEEL PIPE AND FITTINGS**

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
  - 1. Material Group: 1.1.
  - 2. End Connections: Butt welding.
  - 3. Facings: Raised face.
- H. Grooved Mechanical-Joint Fittings and Couplings:
  - 1. Manufacuterers
    - a. Viega
    - b. Victaulic
  - 2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
  - 3. Couplings: Ductile- or malleable-iron housing and EPDM or nitrile gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
- I. Steel Pressure-Seal Fittings:
  - 1. Manufacuterers
    - a. Viega
    - b. Victaulic
  - 2. Housing: Steel.
  - 3. O-Rings and Pipe Stop: EPDM.
  - 4. Tools: Manufacturer's special tool.
  - 5. Minimum 300-psigorking-pressure rating at 230 deg FNon-reinforced, welded, in-branch connections weaken a main pipeline; reinforcement is necessary unless wall thickness of both mains and branches is sufficient to sustain pressure required in "Performance Requirements" Article.

- J. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

## **2.4 JOINING MATERIALS**

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
  - 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
    - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
    - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.
- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- G. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

## **2.5 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Capitol Manufacturing Company.
    - b. Central Plastics Company.
    - c. Matco-Norca.
    - d. Watts Regulator Co.
    - e. Zurn Industries, LLC.



2. Description:
  - a. Standard: ASSE 1079.
  - b. Pressure Rating: 125 psig minimum at 180 deg F
  - c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Capitol Manufacturing Company.
  - b. Central Plastics Company.
  - c. Matco-Norca.
  - d. Watts Regulator Co.
  - e. Zurn Industries, LLC.
2. Description:
  - a. Standard: ASSE 1079.
  - b. Factory-fabricated, bolted, companion-flange assembly.
  - c. Pressure Rating: 125 psig minimum at 180 deg F 150 psig
  - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Capitol Manufacturing Company.
  - b. Central Plastics Company.
  - c. Matco-Norca.
  - d. Watts Regulator Co.
  - e. Zurn Industries, LLC.
2. Description:
  - a. Nonconducting materials for field assembly of companion flanges.
  - b. Pressure Rating: 150 psig
  - c. Gasket: Neoprene or phenolic.
  - d. Bolt Sleeves: Phenolic or polyethylene.
  - e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

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

- a. Capitol Manufacturing Company.
- b. Central Plastics Company.
- c. Matco-Norca.
- d. Watts Regulator Co.
- e. Zurn Industries, LLC.

2. Description:

- a. Standard: IAPMO PS 66.
- b. Electroplated steel nipple, complying with ASTM F 1545.
- c. Pressure Rating: 300 psigt 225 deg F
- d. End Connections: Male threaded or grooved.
- e. Lining: Inert and noncorrosive, propylene.

### **PART 3 - EXECUTION**

#### **3.1 PIPING APPLICATIONS**

- A. Refer to Contract Drawings.

#### **3.2 PIPING INSTALLATIONS**

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.

- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 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 mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- P. Install valves according to Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," Section 230523.14 "Check Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."
- 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 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.
- U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

### **3.3 DIELECTRIC FITTING INSTALLATION**

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.
- D. Dielectric Fittings for NPS 6 and Larger: Use dielectric flange kits.

### **3.4 HANGERS AND SUPPORTS**

- A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.
- B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install the following pipe attachments:
  - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
  - 2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
  - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
  - 4. Spring hangers to support vertical runs.
  - 5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
  - 6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
- D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
  - 1. NPS 3/4: Maximum span, 7 feet.
  - 2. NPS 1: Maximum span, 7 feet.
  - 3. NPS 1-1/2: Maximum span, 9 feet.
  - 4. NPS 2: Maximum span, 10 feet.
  - 5. NPS 2-1/2: Maximum span, 11 feet.
  - 6. NPS 3 and Larger: Maximum span, 12 feet.
- E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
  - 1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
  - 2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
  - 3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
  - 4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
  - 5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
  - 6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
  - 7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.
- F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

### **3.5 PIPE JOINT CONSTRUCTION**

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

- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
  - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
  - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.
- I. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.
- J. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

### **3.6 TERMINAL EQUIPMENT CONNECTIONS**

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

### **3.7 FIELD QUALITY CONTROL**

- A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 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.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

**END OF SECTION 232113**

## **SECTION 232116 HYDRONIC PIPING SPECIALTIES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract.

#### **1.2 SUMMARY**

- A. Section includes special-duty valves and specialties for the following:
  - 1. Hot-water heating piping.
  - 2. Chilled-water piping.
  - 3. Condenser-water piping.
  - 4. Makeup-water piping.
  - 5. Condensate-drain piping.
  - 6. Blowdown-drain piping.
  - 7. Air-vent piping.

#### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of the following:
  - 1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
  - 2. Air-control devices.
  - 3. Hydronic specialties.

#### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

#### **1.5 MAINTENANCE MATERIAL SUBMITTALS**

- A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

## 1.6 QUALITY ASSURANCE

- A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
  - 1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
  - 1. Hot-Water Heating Piping: 150 psig at 200 deg F.
  - 2. Chilled-Water Piping: 150 psig at 200 deg F.
  - 3. Condenser-Water Piping: 150 psig at 150 deg F.
  - 4. Makeup-Water Piping: 80 psig at 150 deg F.
  - 5. Condensate-Drain Piping: 150 deg F.
  - 6. Blowdown-Drain Piping: 200 deg F.
  - 7. Air-Vent Piping: 200 deg F.
  - 8. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.
- B. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached

### 2.2 VALVES

- A. Bronze, Calibrated-Orifice, Balancing Valves:
  - 1. Manufacturers
    - a. Armstrong Pumps
    - b. Bell & Gossett
    - c. Flow Design, Inc.
    - d. TA Hydronics
  - 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 Gage 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 (860 kPa).
10. Maximum Operating Temperature: 250 deg F (121 deg C).

B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers
  - a. Armstrong Pumps
  - b. Bell & Gossett
  - c. Flow Design, Inc.
  - d. TA Hydronics
2. Body: Cast-iron or steel body, ball, 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 Gage 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 (860 kPa).
11. Maximum Operating Temperature: 250 deg F (121 deg C).

C. Automatic Flow-Control Valves:

1. Manufacturers
  - a. Flow Design, Inc.
  - b. TA Hydronics
2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig
9. Maximum Operating Temperature: 250 deg F

## 2.3 AIR-CONTROL DEVICES

A. Manual Air Vents:

1. Manufacturers
  - a. AMTROL, Inc.
  - b. Armstrong Pumps
  - c. Bell & Gossett
  - d. Taco, Inc.

2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2 (DN 15).
6. Discharge Connection: NPS 1/8 (DN 6).
7. CWP Rating: 150 psig (1035 kPa).
8. Maximum Operating Temperature: 225 deg F (107 deg C).

B. Automatic Air Vents:

1. Manufacturers
  - a. AMTROL, Inc.
  - b. Armstrong Pumps
  - c. Bell & Gossett
  - d. Taco, Inc.
2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2 (DN 15).
6. Discharge Connection: NPS 1/4 (DN 8).
7. CWP Rating: 150 psig (1035 kPa).
8. Maximum Operating Temperature: 240 deg F (116 deg C).

C. Bladder-Type Expansion Tanks:

1. Manufacturers
  - a. AMTROL, Inc.
  - b. Armstrong Pumps
  - c. Bell & Gossett
  - d. Taco, Inc.
2. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. Tangential-Type Air Separators:

1. Manufacturers
  - a. AMTROL, Inc.
  - b. Armstrong Pumps
  - c. Bell & Gossett
  - d. Taco, Inc.

2. Tank: Welded steel; ASME constructed and labeled for 125-psig (860-kPa) minimum working pressure and 375 deg F (191 deg C) 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 (DN 50) and smaller; flanged connections for NPS 2-1/2 (DN 65) and larger.
5. Blowdown Connection: Threaded.
6. Size: Match system flow capacity.

E. In-Line Air Separators:

1. Manufacturers
  - a. AMTROL, Inc.
  - b. Armstrong Pumps
  - c. Bell & Gossett
  - d. Taco, Inc.
2. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
3. Maximum Working Pressure: Up to 175 psig (1207 kPa).
4. Maximum Operating Temperature: Up to 300 deg F (149 deg C).

F. Air Purgers:

1. Manufacturers
  - a. AMTROL, Inc.
  - b. Armstrong Pumps
  - c. Bell & Gossett
  - d. Taco, Inc.
2. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
3. Maximum Working Pressure: 150 psig (1035 kPa).
4. Maximum Operating Temperature: 250 deg F (121 deg C).

## 2.4 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig (860 kPa).

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
  2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
  3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
  4. CWP Rating: 125 psig (860 kPa).
- C. Stainless-Steel Bellow, Flexible Connectors:
1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
  2. End Connections: Threaded or flanged to match equipment connected.
  3. Performance: Capable of 3/4-inch (20-mm) misalignment.
  4. CWP Rating: 150 psig (1035 kPa).
  5. Maximum Operating Temperature: 250 deg F (121 deg C).
- D. Spherical, Rubber, Flexible Connectors:
1. Body: Fiber-reinforced rubber body.
  2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
  3. Performance: Capable of misalignment.
  4. CWP Rating: 150 psig (1035 kPa).
  5. Maximum Operating Temperature: 250 deg F (121 deg C).
- E. Expansion Fittings: Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping.

## **PART 3 - EXECUTION**

### **3.1 VALVE APPLICATIONS**

- A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.
- B. Install calibrated-orifice, balancing valves at each branch connection to return main.
- C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.
- D. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

- F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

### **3.2 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 piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
- C. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.
- D. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.
- E. Install expansion tanks above the air separator. 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, fittings, plus tank full of water. Do not overload building components and structural members.
- F. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

**END OF SECTION 232116**

## **SECTION 238236 - FINNED-TUBE RADIATION HEATERS**

### **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 hydronic, finned-tube radiation heaters.

#### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and 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 details and dimensions of custom-fabricated enclosures.
  - 4. Indicate location and size of each field connection.
  - 5. Indicate location and arrangement of piping valves and specialties.
  - 6. Indicate location and arrangement of integral controls.
  - 7. Include enclosure joints, corner pieces, access doors, and other accessories.
  - 8. Include diagrams for power, signal, and control wiring.
- C. Samples: For each exposed product and for each color and texture specified.
- D. Color Samples for Initial Selection: For finned-tube radiation heaters with factory-applied color finishes.
- E. Color Samples for Verification: For each type of exposed finish.

## **1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 1. Structural members, including wall construction, to which finned-tube radiation heaters will be attached.
  - 2. Method of attaching finned-tube radiation heaters to building structure.
  - 3. Penetrations of fire-rated wall and floor assemblies.
- B. Field quality-control reports.

## **PART 2 - PRODUCTS**

### **2.1 HOT-WATER FINNED-TUBE RADIATION HEATERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ritling.
  - 2. Slant/Fin Corp.
  - 3. Sterling HVAC Products; a Mestek company.
  - 4. Trane.
- B. Performance Ratings: Rate finned-tube radiation heaters according to Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."
- C. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One end of tube shall be belled.
- D. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.
- E. Front Panel: Minimum 0.0428-inch- thick steel.
- F. Wall-Mounted Back Panel: Minimum 0.0329-inch-thick steel, full height, with full-length channel support for front panel without exposed fasteners.
- G. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.
- H. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.
- I. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches, integral with enclosure.
- J. Enclosure Style: Sloped top.
  - 1. Front Inlet Grille: Punched louver; painted to match enclosure.

2. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
    - a. Mill-finish aluminum.
    - b. Anodized finish, color as selected by Architect from manufacturer's standard colors.
    - c. Painted to match enclosure.
  3. Outlet Grille: Punched louver; painted to match enclosure.
- K. Accessories: Filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine areas to receive finned-tube radiation heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for hydronic-piping connections to verify actual locations before installation of finned-tube radiation heaters.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 FINNED-TUBE RADIATION HEATER INSTALLATION**

- A. Install units level and plumb.
- B. Install enclosure continuously around corners, using outside and inside corner fittings.
- C. Join sections with splice plates and filler pieces to provide continuous enclosure.
- D. Install access doors for access to valves.
- E. Install enclosure continuously from wall to wall.
- F. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.
- G. Install valves within reach of access door provided in enclosure.
- H. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.
- I. Install piping within pedestals for freestanding units.



### **3.3 CONNECTIONS**

- A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect hot-water finned-tube radiation heaters and components to piping according to Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
  - 1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
- C. Install piping adjacent to finned-tube radiation heaters to allow service and maintenance.

### **3.4 FIELD QUALITY CONTROL**

- A. Perform the following field 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.
- B. Units will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

**END OF SECTION 238236**

## **SECTION 238239.13 - CABINET UNIT HEATERS**

### **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 cabinet unit heaters with centrifugal fans and hot-water coils.

#### **1.3 DEFINITIONS**

- A. CWP: Cold working pressure.
- B. DDC: Direct digital control.
- C. PTFE: Polytetrafluoroethylene plastic.
- D. TFE: Tetrafluoroethylene plastic.

#### **1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and 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 location and size of each field connection.
  - 4. Include details of anchorages and attachments to structure and to supported equipment.
  - 5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
  - 6. Indicate location and arrangement of piping valves and specialties.
  - 7. Indicate location and arrangement of integral controls.
  - 8. Wiring Diagrams: Power, signal, and control wiring.

- C. Samples: For each exposed product and for each color and texture specified.
- D. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.
- E. Samples for Verification: Finish colors for each type of cabinet unit heater indicated with factory-applied color finishes.

## **1.5 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, using input from installers of the items involved:
  - 1. Suspended ceiling components.
  - 2. Structural members to which cabinet unit heaters will be attached.
  - 3. Method of attaching hangers to building structure.
  - 4. Size and location of initial access modules for acoustical tile.
  - 5. Items penetrating finished ceiling, including the following:
    - a. Lighting fixtures.
    - b. Air outlets and inlets.
    - c. Speakers.
    - d. Sprinklers.
    - e. Access panels.
  - 6. Perimeter moldings for exposed or partially exposed cabinets.
- B. Seismic Qualification Data: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC." 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. Include detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

## **1.6 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

## **1.7 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Cabinet Unit-Heater Filters: Furnish [**one**] <Insert number> spare filter(s) for each filter installed.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Carrier Corporation; a unit of United Technologies Corp.
  - 2. Trane.

### **2.2 DESCRIPTION**

- A. Factory-assembled and -tested unit complying with AHRI 440.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with UL 2021.

### **2.3 PERFORMANCE REQUIREMENTS**

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

### **2.4 COIL SECTION INSULATION**

- A. Insulation Materials: ASTM C1071; surfaces exposed to airstream shall have aluminum-foil facing to prevent erosion of glass fibers.
  - 1. Thickness: 1/2 inch.
  - 2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F mean temperature.
  - 3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84.
  - 4. Adhesive: Comply with ASTM C916 and with NFPA 90A or NFPA 90B.
  - 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

## **2.5 CABINETS**

- A. Material: Steel with factory prime coating, ready for field painting.
  - 1. Vertical Unit, Exposed Front Panels: Minimum 0.0528-inch- thick galvanized sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
  - 2. Recessed Flanges: Steel, finished to match cabinet.
  - 3. Control Access Door: Key operated.
  - 4. Base: Minimum 0.0528-inch-thick steel, finished to match cabinet, 4 inches high with leveling bolts.
  - 5. Extended Piping Compartment: 8-inch- wide piping end pocket.
  - 6. False Back: Minimum 0.0428-inch-thick steel, finished to match cabinet.

## **2.6 FILTERS**

- A. Minimum Efficiency Reporting Value and Average Arrestance: According to ASHRAE 52.2.
- B. Minimum Efficiency Reporting Value: According to ASHRAE 52.2.
- C. Material: Pleated cotton-polyester media, MERV E.

## **2.7 COILS**

- A. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and 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.

## **2.8 CONTROLS**

- A. Fan and Motor Board: Removable.
  - 1. Fan: Forward curved, double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
  - 2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 3. Wiring Terminations: Connect motor to chassis wiring with plug connection.
- B. Factory, Hot-Water Piping Package: ASTM B88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
  - 1. Hose Kits: Minimum 400-psig working pressure, and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.
    - a. Length: 24 inches.
    - b. Minimum Diameter: Equal to cabinet unit-heater connection size.

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 venture, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
4. Automatic Flow-Control Valve: Brass or ferrous-metal body, 300-psig working pressure at 250 deg F, with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow within plus or minus 10 percent of differential pressure range of 2 to 80 psig.
5. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A126, Class B); 125-psig minimum working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 threaded pipe and full-port ball valve in strainer drain connection.
6. Wrought-Copper Unions: ASME B16.22.

C. Basic Unit Controls:

1. Control voltage transformer.
2. Unit-mounted thermostat with the following features:
  - a. Fan on-auto switch.
  - b. Manual fan-speed switch.
  - c. Adjustable deadband.
  - d. Concealed set point.
  - e. Concealed indication.
  - f. Deg F indication.
3. Unit-mounted temperature sensor.
4. Unoccupied period override push button.
5. Data entry and access port.
  - a. Input data includes room temperature and occupied and unoccupied periods.
  - b. Output data includes room temperature, supply-air temperature, entering-water temperature, operating mode, and status.

D. Interface with DDC System for HVAC Requirements:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at central workstation.
3. Interface shall be BAC-net compatible for central DDC system for HVAC workstation and include the following functions:
  - a. Adjust set points.
  - b. Cabinet unit-heater start, stop, and operating status.
  - c. Occupied and unoccupied.

E. Electrical Connection: Factory-wired motors and controls for a single field connection.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas to receive cabinet unit heaters 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 unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."
- B. Install cabinet unit heaters to comply with NFPA 90A.
- C. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.
- D. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

### **3.3 CONNECTIONS**

- A. Piping installation requirements are specified in Section 232113 "Hydronic Piping," Section 232116 "Hydronic Piping Specialties". Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.
- D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
- E. Comply with safety requirements in UL 1995.
- F. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of cabinet unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

- G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- H. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### **3.4 FIELD QUALITY CONTROL**

- A. Perform the following tests and inspections:
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

### **3.5 ADJUSTING**

- A. Adjust initial temperature set points.

### **3.6 DEMONSTRATION**

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

**END OF SECTION 238239.13**